POWER PLANT ENGINEERING

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The Tamarack Power Plant

PLANT SUPPLYING POWER TO THE LARGEST PRODUCERS OF TIRE FABRIC IN THE COUNTRY DESIGNED BY ITS OPERATING ENGINEER

FURNISHING POWER to the largest producers of automobile tire fabric in the country, the Tamarack Power Plant of the Jenckes Spinning Company at Pawtucket, R. I., is unquestionably one of the finest and most up-to-date mill plants in New England. Spotless, roomy, as smooth running as a high grade watch, this power plant is as nearly perfect, particularly from an operating standpoint, as modern engineering practice is capable of making it. Every valve, every piece of equipment installed in the entire plant has been located and placed in a position which will allow of the least discomfort to the operator for its manipulation. To the casual observer it may appear as though there is a great deal of useless space in this plant; this, however, is not the case. All of the apparent waste space has been purposely provided, and as analysis will reveal, contributes to the better operation of the plant.

In the design and construction of power plants, the operator's viewpoint is too often entirely overlooked, and, while the resulting plants may be efficient from a thermo-dynamic standpoint, they are, as a rule, sadly lacking in those features which make for a contented operating crew. Equipment is too often installed without considering its operability. A valve which is installed in a position such that only a trained acrobat can reach it, obviously will not receive as much attention and care as it would if it were placed in a more accessible position.

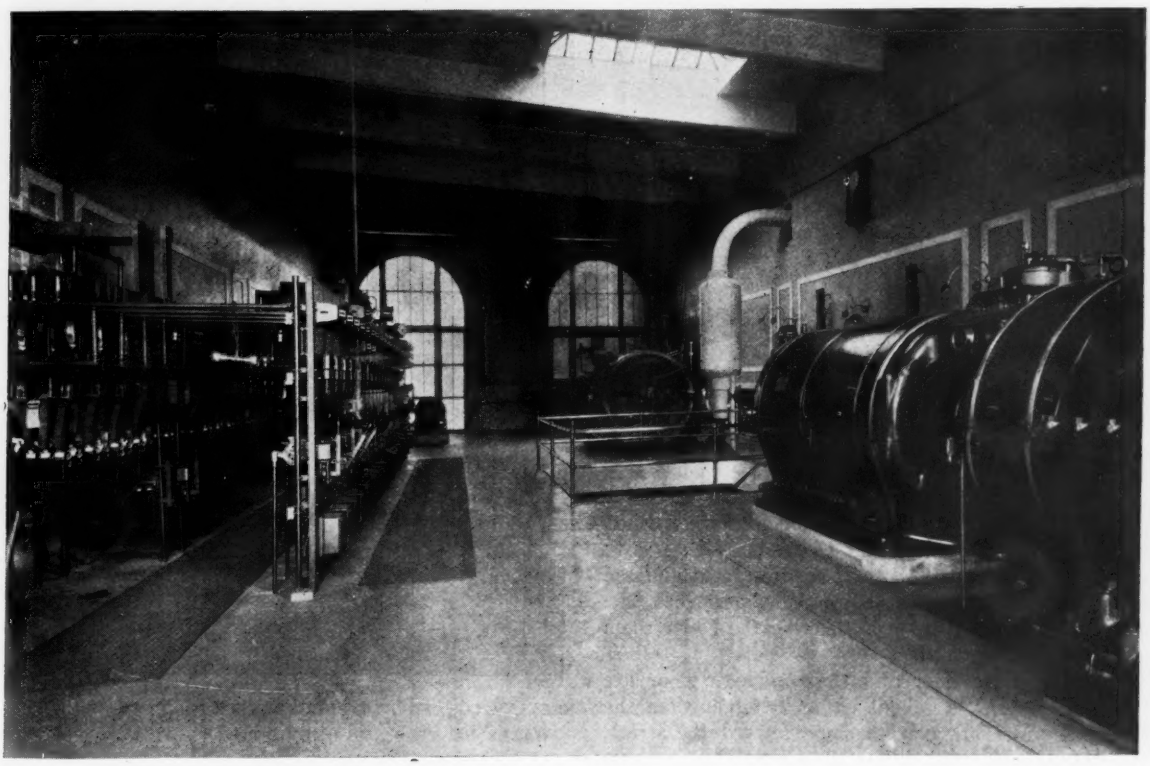


FIG. 1. GENERAL VIEW IN TURBINE ROOM, TAMARACK PLANT

The Tamarack plant, having been designed and constructed under the direct supervision, and according to the ideas of the operating engineer, has incorporated in it every feature which will improve and simplify operation. Mr. Tefft, the operating engineer, has been in the service of the company over 25 years, and a few years ago when it became necessary to build a new plant, full confidence was reposed in him. He was given full responsibility and constructed the plant from a practical viewpoint.

General Features

An exterior view of the power plant is shown in Fig. 6. The building, as may be noted, is approximately 40 ft. in height and is of brick, steel and concrete construction. The exterior is faced with red pressed brick.

FIG. 2. VIEW IN BOILER ROOM

One of the first things Mr. Tefft decided upon when planning the plant was that the entire building was to be of one height; that is, both the boiler room and the turbine room ceiling were to be at the same level. The height was determined upon by making the boiler room 40 ft. from floor to ceiling.

The boiler room floor and the condenser floor are at the same level, i. e., about an inch higher than the street level and laid so as to slope toward the street, and nothing is located below this level. With this arrangement, in case of a flood due to an accident to one of the pump lines, it will merely be necessary to open the doors and to allow the water to drain out.

Another thing upon which special emphasis was placed was the provision of ample space for each piece of equipment. Plenty of space is, therefore, provided behind and above the boilers so that tubes may be replaced and the boilers cleaned with the least inconvenience to the workmen. The condenser floor was made high purposely, so that maximum comfort and efficiency in operation could be secured.

Ample natural illumination is secured throughout the entire plant by the judicious location of large windows and skylights, in fact, the only place where artificial illumination is at all required is on the condenser floor underneath the turbine room, and on bright days it can be dispensed with even in this room.

Tamarack No. 2 as this plant is called is one of three power plants furnishing power to the Tamarack Co. and the Jenckes Spinning Co. The other two plants are older plants but are still in full operation. These power plants are also tied in with the high tension lines of the local public service company's lines at all times.

Oil Used as Fuel

As is the case in many industrial power plants in New England, this plant uses oil as fuel. Because of the prevailing high price of coal, it has been found more economical to burn oil and as a consequence many plants in this section of the country are converting their coal burning plants into oil fired plants. Mexican oil is used, this being conveniently transported by steamships to the refineries in New England.

Steam is generated at a pressure of 155 lb., 100 deg. superheat, in ten 400-hp. Babcock & Wilcox double drum

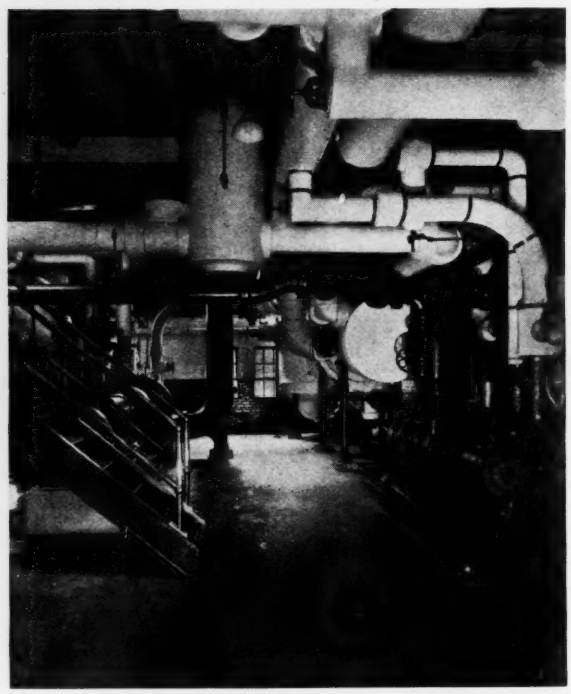


FIG. 3. A CORNER OF THE CONDENSER FLOOR SHOWING FEED WATER HEATERS AND ONE OF THE BOILER FEED PUMPS

water tube boilers. These boilers are 14 ft. wide, 14 ft. high and are fitted with 196 4-in. tubes, 18 ft. long. The drums are 42 in. in diameter by 20 ft. 5½ in. long and are constructed of 7/16-in. open hearth steel having a tensile strength of 56,000 lb. per sq. in.

Although ordinary hand-fired furnaces were furnished with each of the boilers, the grates have been removed and each unit fitted with two Hammel back

or undershot type oil burners. To adapt the boilers to oil firing, special attention has been given to the furnace linings.

The fuel oil is heated to a temperature of from 140 to 150 deg. F. in a Hammel system heater and is delivered to the burners under a pressure of about 70 lb. into contact, and the oil is atomized inside of the burner itself, the mixture issuing from the burner tip ready for combustion at once. Oil enters at A in Fig. 12, flows through D into the mixing and atomizing chamber C; steam enters at B, passes through F, E, and then through three small slots, G, H, and I into the mixing chamber

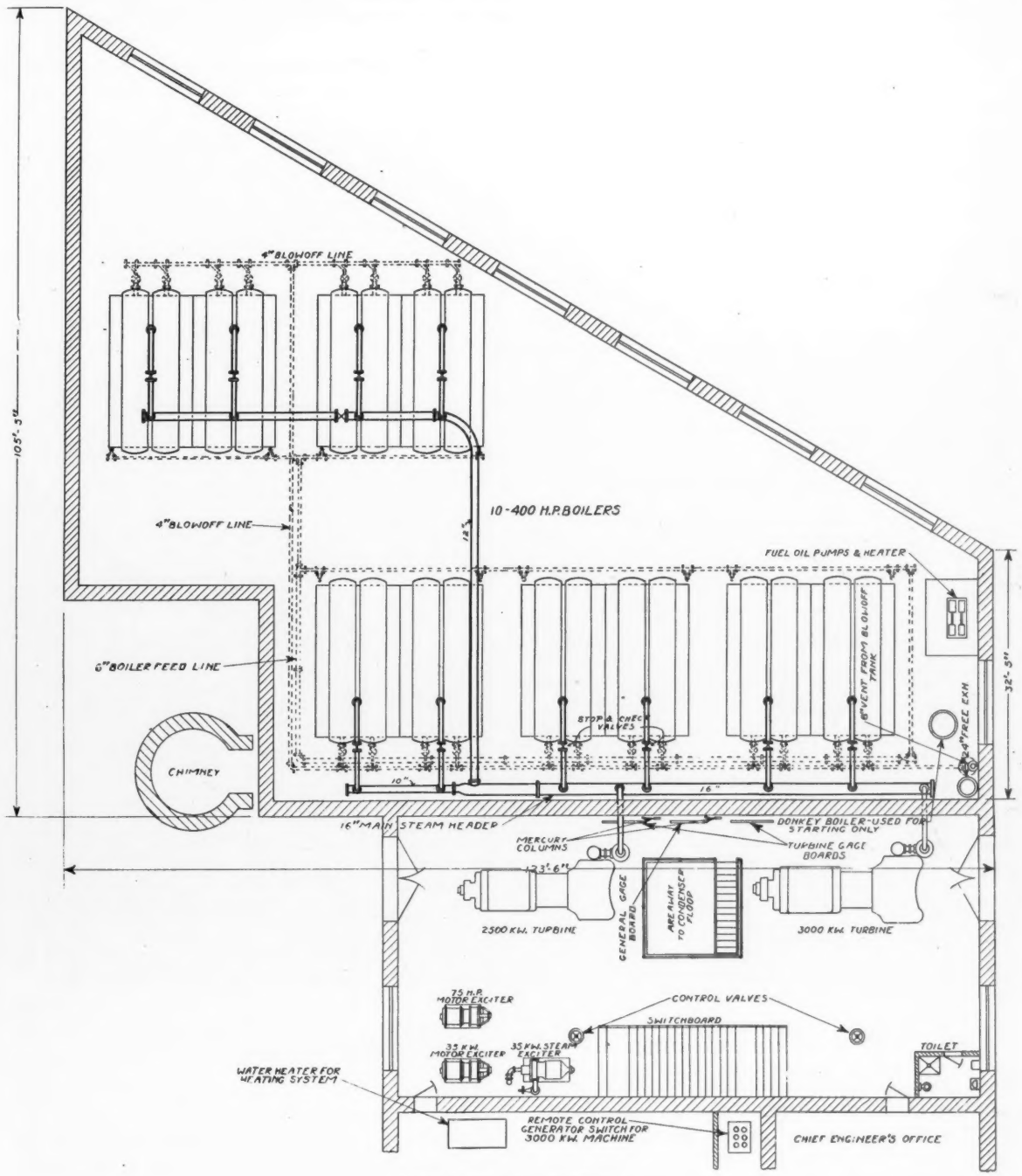


FIG. 4. PLAN OF STATION

The oil pressure is maintained constant by means of a Watt pressure governor. An evaporation of about 15 lb. of water per pound of oil is maintained.

The burner used is of the inside mixer type shown in Fig. 12. In burners of this class, the steam and oil come C where it meets the oil, and as these small steam jets cut across the oil stream at an angle, the energy of the steam is utilized.

Excellent results are obtained in burning oil and the saving in labor costs over that which would be

required if coal were burned has proved an important factor in increasing the overall economy.

Steam is taken from the boiler through 6-in. lap welded steel headers in the form of vertical 180-deg. bends as shown in Fig. 5. Each header is fitted with a 6-in. Schutte & Koerting cast steel stop and check valve and a 6-in. Chapman gate valve.

The main steam header is shown in Fig. 4. It is constructed of 10, 12, and 16-in. diameter lap welded steel pipe. Behind the boilers it is supported by rollers on wall brackets while the section which is installed above the boilers is suspended by rods from the ceiling beams. Line condensation is taken care of by 6-in. Crane drip pockets and Squires steam traps. These traps discharge into the hot well.

Each boiler is fitted with two, 2½-in. blowoff lines connecting into a 3 by 8 ft. cast iron blowoff tank installed in a concrete compartment below the floor. The individual blow lines from the boilers are fitted with Cadman blowoff valves and with Chapman gate valves. Expansion in the main blowoff line is taken care of by a Walworth expansion joint.

Feed water is distributed through 4 and 6-in. cast iron feed mains installed in a trench below the floor level and is delivered to the boilers through 2-in. brass feed lines. The feed water used is city water of good quality and needs no chemical treatment. The boiler tubes are cleaned about once every two years as very little scale forms.

The Turbine Room

The turbine room is located adjacent to the boiler room, on the second floor of that portion of the building. As may be noted from the photograph, Fig. 1, this room presents an exceptionally attractive appearance. The walls are plastered, painted a light cream color, trimmed in white. The ceiling, which is also plastered, is finished in white. The floor is of smooth cement.

Abundant natural illumination is provided through large windows at both ends of the room and by a skylight in the center, so that during the day artificial illumination can be entirely dispensed with. At night the room is lighted by large gas-filled incandescent lamps installed in ceiling fixtures and fitted with glass reflectors.

The arrangement of mechanical equipment is symmetrical and simple. Two turbo-generators are installed along one side of the room while a 21-panel switchboard occupies the opposite side.

An areaway to the condenser floor surrounded by brass railings is located in the center of the room between the turbo-generators.

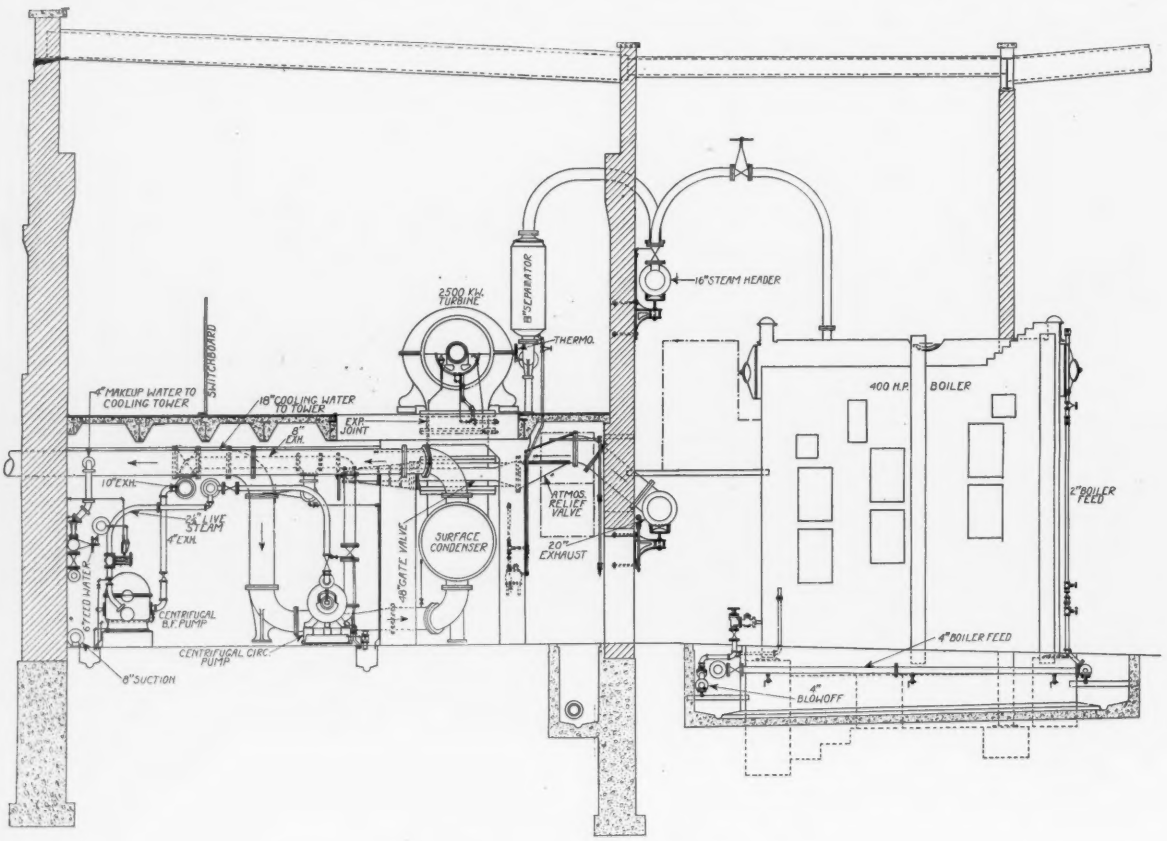


FIG. 5. CROSS SECTIONAL VIEW OF POWER PLANT

Generating Equipment

Electricity is generated at 600 v., 60 cycles by two General Electric, alternating current generators direct connected to two Curtis type steam turbines of the same manufacture. Both are condensing turbines operating

at 3600 r.p.m. with 150 lb. steam pressure. Unit No. 1 is rated at 2500 kw. and No. 2 at 3000 kw.

The generators are identical in construction except as to size. No. 1 is rated at 3150 kv.a., 80 per cent power factor, 3007 amp., while No. 2 has a rating of 3750 kv.a., 80 per cent power factor, 3608 amp.

Excitation current for the above mentioned machines is provided by three separate exciter units, with ratings as follows:

No. 1. A 50-kw. G. E. compound wound direct current generator, 400 amp., 125 v., 1200 r.p.m., driven by a 75-hp. G. E. induction motor, 550 v., 71 amp., three-phase, 60 cycles.

No. 2. A 35-kw. G. E. direct current generator, 280 amp., 125 v., 1200 r.p.m., direct connected to a 50-hp. G. E. induction motor, 550 v., 48 amp., three-phase, 60 cycles.

No. 3. A 35-kw. G. E. direct current generator, 125 v., 280 amp., direct connected to a G. E. Curtis steam turbine operating at 3600 r.p.m.

All the exciters are arranged to feed to a common exciter bus. Ordinarily, when only the 3000-kw. turbo is running, the 50-kw. exciter is used. When both turbos are in operation, the two motor driven exciters are used. The turbine driven set is used only in case the entire alternating current supply fails. In case of such an event, it is used only to start one of the turbo-generating units, and as soon as the latter has come up to speed and is generating, the motor driven exciter is cut in while at the same time, the turbine driven unit is shut down.

Voltage regulation of the generating units is accomplished by means of a Tirrill regulator operating on the exciter bus. The exciter bus voltage is maintained at approximately 92 v.

The 2500-kw. turbine is of the bleeder type; steam being taken from the low pressure stages for feed water heating purposes.

Air for cooling the generator windings is taken through a sheet iron duct from the outside of the buildings. A common intake is provided for both generators but each has its individual discharge.

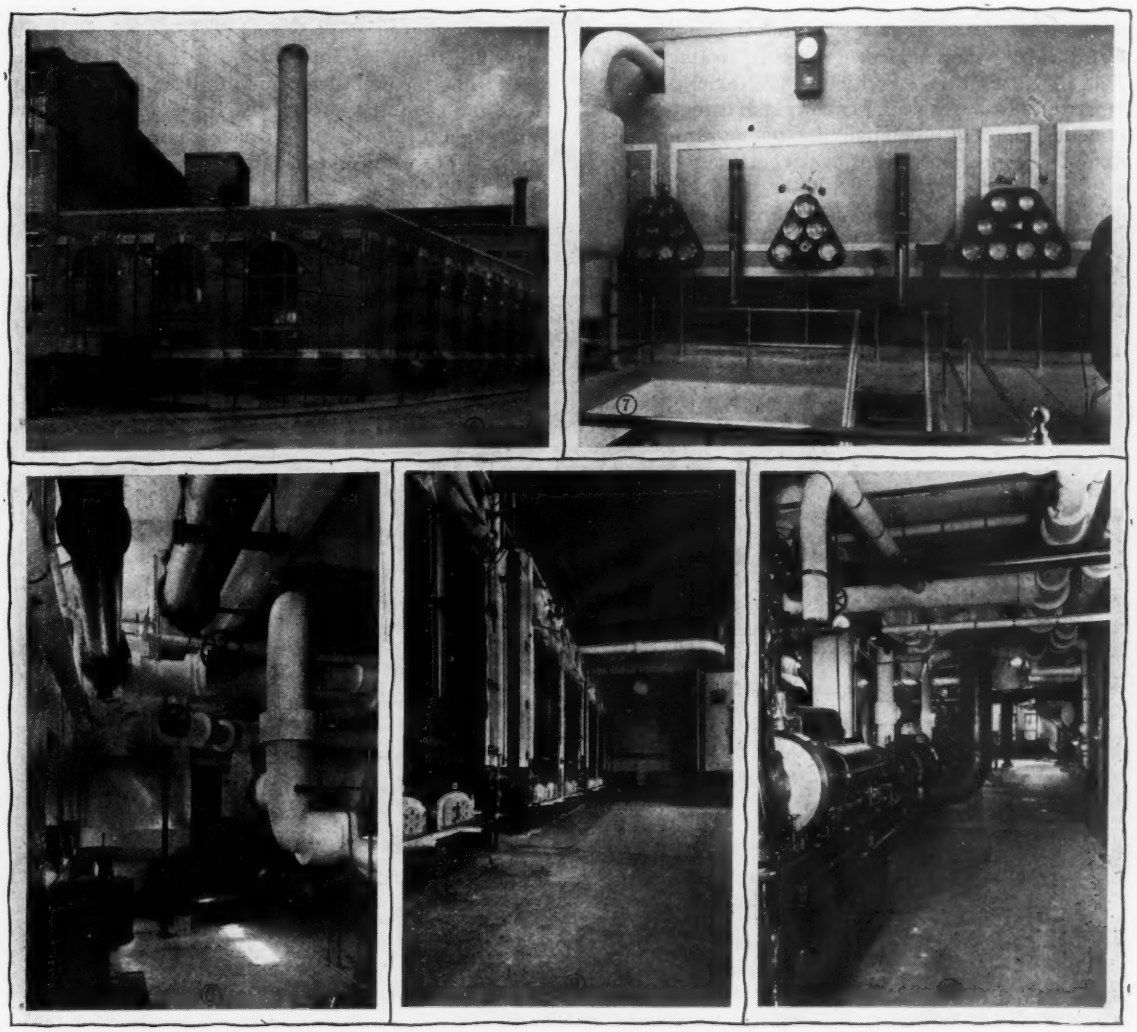


FIG. 6. EXTERIOR VIEW OF TAMARACK PLANT. FIG. 7. THE TURBINE ROOM INSTRUMENT BOARDS. FIG. 8. CORNER OF THE CONDENSER FLOOR SHOWING FEED WATER HEATERS. FIG. 9. ANOTHER VIEW OF THE BOILER ROOM. FIG. 10. ROTREX AIR PUMP AND CIRCULATING UNIT FOR 2500 KW. TURBINE UNIT

To anticipate trouble due to overheating, each generator is fitted with Foxboro temperature indicators of the regulator dial type.

The turbine instrument boards are shown in the photograph, Fig. 7. Each turbine board contains the following instruments:

3 Indicating thermometers: condenser inlet temp.; condenser discharge temp.; turbine exhaust temp.

1 Speed indicator.

1 Indicating vacuum gage (vacuum in condenser).

1 Indicating pressure gage (steam, 1st stage).

1 Recording thermometer (temp. generator stator).

1 Recording vacuum gage (vacuum in condenser).

1 Indicating thermometer (water to cooling tower).

The above, with the exception of the General Electric Co. speed indicator, are all Foxboro instruments and, as is evident from the accompanying photograph, the installation presents an exceptionally attractive appearance.

The general turbine room gage board is shown located between the two turbine boards. This is also fitted with Foxboro instruments for indicating steam pressure, pressure in heating mains, city water pressure, and for recording feed water pressure, steam pressure, and feed water temperature.

There are also installed two mercury columns, a 4-in. Venturi meter and two water level gages. The latter are shown above the mercury columns and consist of a number of small incandescent lamps mounted in a vertical row to indicate the water level in the cooling tower tanks upon the roof. These water level gages are also equipped with electric bell alarms to notify the engineer of either extreme high or extreme low water level.

The instrument equipment at this plant, of which the gage boards in the turbine room are typical examples, is of particular excellence; instruments are installed to furnish information regarding all important operating performance. In this connection, it may be stated that a comprehensive system of records enables the management to determine the operating and maintenance costs with the least amount of effort. A typical daily power report sheet is shown in Fig. 14.

Auxiliaries

Condensing water is a scarce commodity at the Tamarack plant, and it is therefore necessary to cool the circulating water by means of three large C. H. Wheeler cooling towers located on the roof of the plant. There are two towers provided for the Tamarack plant, that is, one for each generating unit, and a third is provided for cooling the condensing water at the Jenckes Spinning Co. plant. The Tamarack towers are 130 ft. long, 20 ft. wide and 35 ft. in height. The Jenckes tower is 90 ft. long, 20 ft. wide and 35 ft. in height.

Each of the two generating units is served by a

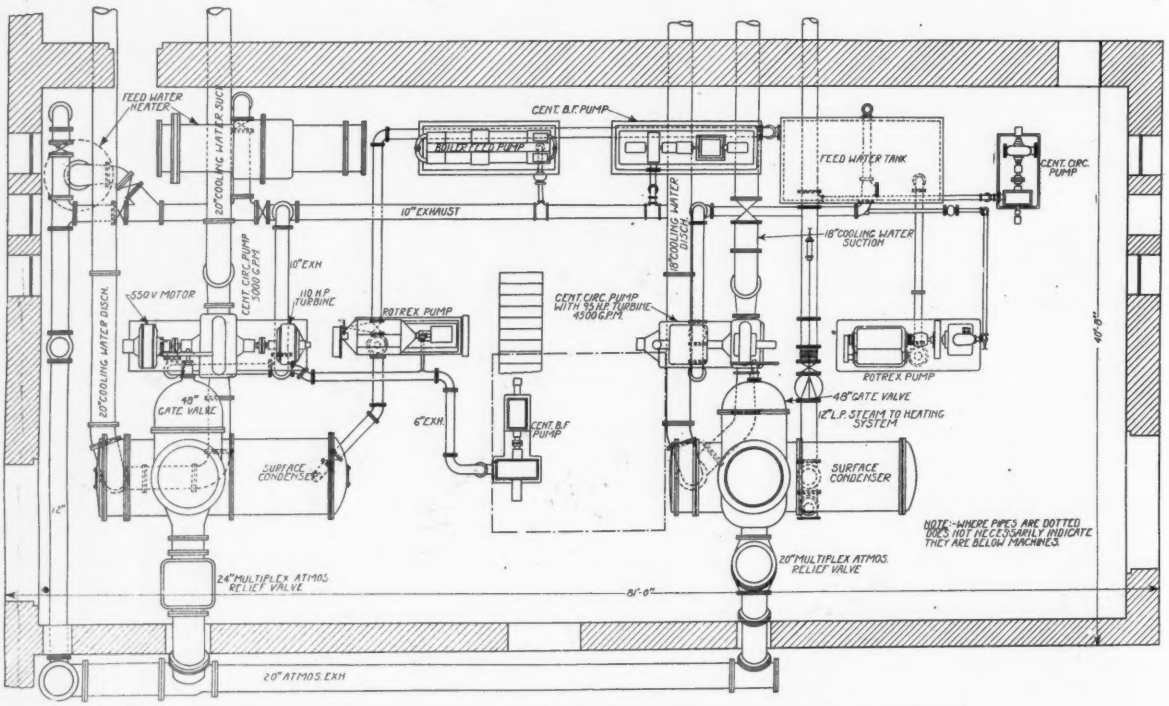


FIG. 11. PLAN OF CONDENSER FLOOR SHOWING ARRANGEMENT OF EQUIPMENT

C. H. Wheeler surface condenser of the circular shell type, having approximately 6000 sq. ft. of surface. They are fitted with ¾-in. tubes 14 ft. long.

The large condenser is capable of condensing the steam from a 3000-kw. turbine when it is receiving at the throttle 50,100 lb. steam per hr. and will maintain a vacuum of 3 in. absolute when supplied with 5000 gal. of injection water per min. from a cooling tower operating under atmospheric conditions of 70 deg. F. and 70 per cent humidity.

Both condenser units are provided with C. H. Wheeler Rotrex air pumps, one an 18 by 36-in., and the other a 17 by 34-in., both driven by small vertical steam engines.

Centrifugal circulating pumps are installed. One,

the unit serving the large condenser, is driven by a General Electric steam turbine at one end and by a 100-hp., 550-v. General Electric motor at the other. This furnishes a flexible arrangement which not only aids in maintaining a proper heat balance, but also provides an alternative means of drive in case one of the driving units fails. The other circulating pump is driven only by a 95-hp. 1800-r.p.m. steam turbine. Foxboro indicating vacuum and altitude gages are installed in connection with both condenser units; these being mounted on a panel adjacent to the condensers.

Condensate from various parts of the plant is returned to a large cast iron hot well, located next to the wall on the condenser floor as shown in Fig. 11.

Two feed water heaters are provided, one a horizontal closed type heater made by the C. H. Wheeler Co. and the other a Reilly Type C, two-pass heater.

Feed water is delivered to the boilers by three feed pumps two of which are turbine driven centrifugal pumps and the other a Smith-Vale duplex outside packed plunger pump, size 10 by 7 by 12 in. The centrifugal pumps are rated as follows: One is a Platt 350-gal. per min. pump, 462 ft. head driven at 2800 r.p.m. by a Lee steam turbine; the other is of Morris Machine Works manufacture, direct connected to a 100-hp. Lee steam turbine operating normally at 3000

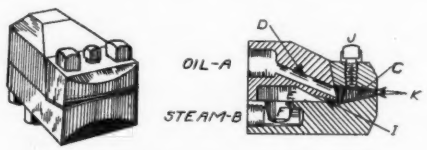


FIG. 12. TYPE OF OIL BURNER USED

r.p.m. Under normal conditions, either of the two centrifugal pumps is capable of carrying the load. The duplex pump is used only at night when the load is very light.

All heating of the mill buildings is accomplished by a hot water circulating system. This water is heated in two closed heaters, one an Alberger and the other a Griscom Russell, installed in the room adjacent to the turbine room. Two pumps are provided to circulate the

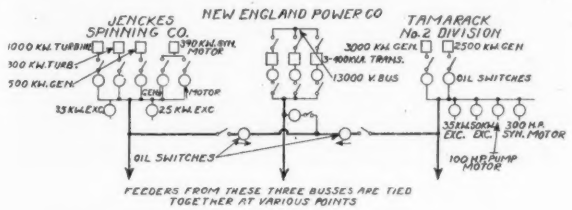


FIG. 13. SIMPLIFIED DIAGRAM OF ELECTRICAL SYSTEM

water through the heating system. These may be described as follows: No. 1, a Goulds centrifugal, capacity 725 gal. per min., head 54 ft., driven at 1750 r.p.m. by a Lee steam turbine. No. 2 is a Morris centrifugal pump, also driven by a Lee turbine.

Electrical Features

Current is controlled and distributed by means of a 21-panel switchboard, of standard General Electric Co. construction. As may be noted from the photograph, Fig. 1, the board is located about 10 ft. from the wall so that ample space is provided for adjustment and inspection of the oil circuit breakers. The latter with the exception of the 3000-kw. generator switch, are all installed against the wall. The 3000-kw. generator switch is located in a separate compartment on the other side of the turbine room wall. In the photograph, the leads to this switch may be seen passing through a rectangular opening in the wall.

All oil circuit breakers except the 3000-kw. generator switch are hand operated through rods and bell cranks from the front of the board. The generator switch is remote controlled by General Electric solenoid control. The field rheostat for this generator is also electrically controlled from the switchboard.

This switchboard can be tied in with the switchboard at the Jenckes Spinning Co. and also with the lines of

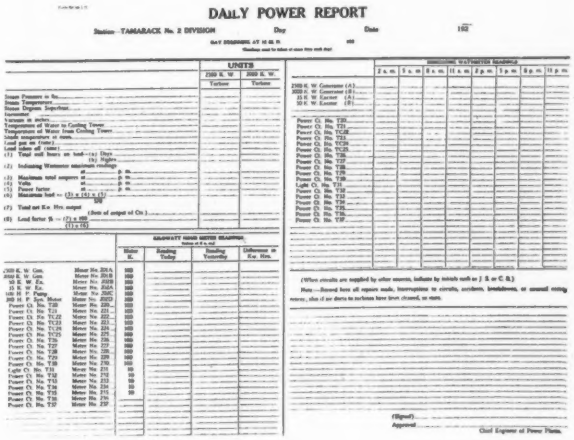


FIG. 14. TYPICAL DAILY POWER REPORT

the New England Power Co. The latter company feeds into the systems through three sets of 13,000/600-v. transformers as shown diagrammatically in Fig. 13, which is an outline of the electrical system.

Conclusion

In concluding the description of this plant, it may be of interest to know that a kilowatt of electrical energy is put on the switchboard for five mills less than the best price at which the public service company is able to supply it. This effects a saving of approximately $60,000 a year at Tamarack and of $120,000 a year in both Tamarack and the Jenckes plant.

The total amount of capital invested in both plants is approximately $500,000. The plant therefore pays for itself in about five years, and after that actually earns $120,000 a year. These figures include all factors of expense, such as operation, maintenance, insurance, depreciation, repair, interest on invested capital, etc.

For privileges extended in the work of gathering material used in the preparation of this article credit is hereby extended to R. L. Brunet, plant engineer, and to Mr. Tefft, chief engineer of the power plant, both of the Jenckes Spinning Co.; also to Jenks and Ballou, of Providence, R. I., who were the consulting engineers.

Coal, From Working Face to Power Plant

A Brief Discussion of the Mining and Preparation of Coal, and How It Affects the Consumer. By A. C. Callen*

CONSUMERS think of coal as something that is black and which will burn; miners think of it as something which is black and which they must shoot down and load into cars. Both are right—but a great deal may happen to make the "coal" which the power plant receives differ considerably from the "coal" as it is in the ground.

Origin of Coal

In order to understand thoroughly the various points in the preparation of coal it is necessary to consider briefly the origin of coal and the various types of impurities associated with it. There are several theories

FIG. 1. A PICKING TABLE

regarding the origin of coal, but it is almost universally believed that coal is of vegetable origin. The great majority of modern geologists also agree that this vegetable matter accumulated in place in about the same way as it is accumulating in some of our large swamps today. These huge swamps were far greater in extent than any peat bogs or swamps which we know of at the present time. They were near sea level so that floods or a slight sinking of the earth's surface would permit sediment from the adjacent country to be washed in on top of the decaying vegetation, thus forming layers of impurities. Hundreds, if not thousands, of years were required for the accumulation of sufficient vegetable material to form a single coal seam, and many thousands of years have elapsed since then during which heat, pressure and other agencies have metamorphosed these accumulations of vegetation into the coal as it is in the ground today.

Nature of Impurities

There are four general classes of impurities which may be present in coal, and it is important to understand them, for some cannot be removed from the coal.

1. The inherent or inseparable impurities. It is well known to botanists that all plants contain some mineral matter and some sulphur. These are present in coal as inherent ash and organic sulphur and cannot be removed by any known means. Some coals may have as little as 1.5 per cent of inherent ash, but most of them will have between 2.5 and 5 per cent, and some still higher percentages. If some sediments were deposited with the vegetal matter under regular uniform conditions the whole seam will be high in inherent ash. If the conditions were irregular, bands of high inherent ash coal—perhaps up to 50 per cent or more ash—will be formed between layers of good coal. These high ash bands are called "bone coal," and may be considered as belonging to class 2. Organic sulphur may be present from fractions of a per cent up to over 2 per cent. It is combined with the coal material and is not visible to the eye.

2. Sedimentary, interbedded or separable impurities. These were introduced into the vegetal material at the time it was laid down, and are present as "binders," "bands," or "slate." If these bands are not too thin, they may be removed by hand picking or by "washing."

3. Infiltrated or subsequent impurities. These have come into the coal after its formation by means of underground circulating waters. Pyrite, the brassy-yellow mineral commonly called "sulphur," is the chief of

FIG. 2. HAND PICKING DURING LOADING

these impurities. It may be present in the form of nodules or balls, as lenses, as bands or as flakes. The flake forms are almost impossible to separate from the coal, but the other forms, owing to their greater size, can usually be removed, if present in sufficient quantity, by hand picking or by washing.

Calcite and gypsum (carbonate and sulphate of lime, respectively) may sometimes be present as white flakes or plates on the cleavage faces of the coal. Their amount is small and, except for the sulphur contained in the gypsum, they have no bad effect on the coal outside of

*Professor of Mining Engineering, West Virginia University.

the small increase in the percentage of ash which they cause. It is impossible to separate them from the coal.

4. Mining impurities. Shale, slate and fireclay may get into the coal during mining. The under cutting machines may cut into the bottom underlying the coal. The roof over the coal may be soft or flaky, and easily be mixed with the coal either as a result of shooting or by spalling off after the coal is down. The loader, shovelling off a soft bottom, may load some of the bottom with the coal. If these impurities become mixed with the coal, it is hard to remove them unless they are of considerable thickness. From their very nature, they tend to break up on handling and go into the finer sizes. If the coal is washed, the fireclay goes to pieces in the water and comes over with the coal.

Another "impurity" in coal is water. It is present in all coals, but in varying amount. Eastern coals have about one or two per cent when mined, while Middle West coals will have from 10 to 18 per cent. The coal dries out considerably during shipment and has lost some of its original moisture by the time it reaches the consumer.

Preparation of Coal

When the coal is brought from the mine to the outside it is ready for preparation, which may include screening, hand or mechanical picking, and washing.

The primary function of screening is to separate the coal into sizes which the trade demands. All tipples can ship run of mine, that is, coal just as it comes from the mine. The simplest sizing is to pass the coal over bars spaced about 1¼ in. apart, thus making two products—screenings and lump coal. Round hole screens may be substituted for the bars. The demand for sized coal has led to the introduction of a great number of sizes and the building of large and expensive screening plants. It is a question whether the demand for closely sized bituminous coal is warranted, although anthracite requires close sizing for proper combustion.

Another reason for sizing is the need for getting the coal ready for efficient hand picking or for washing. Both operations require suitable sizing.

Removing Impurities by Picking

From the discussion of the various classes of impurities it is evident that the only ones which can be removed by picking are the pieces of slate and bone that may have been interbedded with the coal and are of sufficient size to be picked, lumps of pyrite, and the larger pieces from the roof or floor that may have become mixed with the coal as it was mined or loaded.

Picking begins at the working face. The miner is not allowed to load refuse with his coal, and is docked when he sends out dirty coal. With the poor light and a mixture of all sizes of coal, however, he cannot be expected to remove any but the larger impurities.

It would be hard to pick pieces of slate ½ in. thick from run of mine coal, for the picker would watch for the large pieces and neglect the small ones. So sizing is a necessary preliminary to picking, and each size is picked separately. Slack coal or screenings is seldom picked, for the pieces are too small to warrant the attempt. Figure 1 shows a picking table. Coal from the inclined shaking screens falls on the picking table which is at right angles to the screens. This table has a traveling belt of steel plates moving at the rate of about 50 ft. per min. The number of men used for picking will depend on the amount of impurities present. The impurities are thrown into a vertical chute leading to a refuse bin below.

Mechanical pickers, whose action depends on the difference in shape and in sliding properties of pieces of coal and slate, are used to some extent in the anthracite region and by one bituminous company.

Sometimes occasional lumps of slate or binder get into the coal, but the amount present would not warrant the use of picking tables. Such coal is frequently picked as the coal is loaded into the car, as shown in Fig. 2.

Loading Booms

In order that coal which has been carefully sized may be loaded with the minimum of breakage, loading booms are used. The loading boom is frequently an extension of the picking table with one end connected to a motor hoist so it may be raised and lowered. Figure 3 shows how short the drop may be to load coal in this way. A man on the tipple controls the loading boom and keeps it at the proper height to load the coal with the least breakage. The man on the car is picking out the last traces of refuse. This figure also shows how well a car may be trimmed by means of a loading boom.

FIG. 3. LOADING BOOMS AT A SOUTHERN WEST VIRGINIA MINE

Coal Washing

In cases where the impurities are too small or too numerous to be removed by picking, washing is frequently used. Coal washing is somewhat of a misnomer, for while the operation takes place in water, the coal is not washed in the usual sense of the term. Machines called jigs are used for all but the finest sizes. Their operation depends on the fact that the coal is lighter than the refuse; the raw coal is fed to the jig and attempts to settle against a pulsating current of water; the refuse, being heavier, sinks while the coal is discharged over the top.

Washed coal is lower in ash and sulphur than the raw coal, but the amount of reduction depends on the forms in which the ash or sulphur was present. Obviously inherent ash and organic sulphur cannot be removed and flake pyrite, calcite and gypsum, even if broken free from the coal, will usually go over with the coal, as their flaky form helps them to float near the surface. Even large particles of fireclay may go to pieces in the water and the fine particles will then go over with the coal.

A device using air, as a separating medium, instead of water, has recently been placed on the market. This will remove the disadvantages caused by the use of water.

Effect of Sizing

The mine does not attempt to dictate what size of coal is best suited to the power plant's needs, for each plant must determine that for itself. It might be well, however, to call attention to the fact that prejudices should not be allowed to decide vital points when actual facts and tests can be secured. Close sizing has gotten to be somewhat of a fad, and it should be remembered that it is false economy to specify some particular size unless a good reason exists therefor.

One particular bubble of prejudice that needs to be burst is that regarding the high ash content of screenings. It is not necessarily true that screenings have a higher percentage of ash than run of mine coal. It will depend on the nature of the impurities and on the comparative friability of the coal and refuse. With some coals the ash content of screenings will be high; with other coals, low. For example, an analysis made in my own laboratory, from a 2-T. sample of coal from perhaps the best known seam in this country, shows 10 per cent ash. The coal below ¾-in. runs about 9½ per cent, while that above ¾-in. shows somewhat over 12 per cent. The opposite results were shown in a sample from another well-known seam where the coal above 2 in. ran about 8¼ per cent ash while there was 9 per cent in the screenings. It is possible that in a majority of cases the screenings may be higher in ash than the nut, egg, and lump, but it is not necessarily true. Screenings, if they can be burned satisfactorily, may in many cases be superior to the larger sizes, particularly if the larger sizes have not been picked.

Degradation

Coal is naturally brittle or friable. Some coals have such well defined cleavage planes that a lump seems to fly in pieces if it is touched. In fact, degradation or breakage occurs every time coal is handled, and the hardest coals are no exception to the rule. The opportunities for breakage are many—the coal is shot down, loaded into cars, hauled perhaps 2 mi. to a shaft, suddenly dumped into a weigh basket at the top of the shaft, dropped onto the screens, shaken and rolled over and over in the screens, down a steep chute into the railroad car, hauled a hundred or five hundred miles to the consumer, dumped into the boot of an elevator, then to a bin from which it is used. It must be evident that where closely sized coal is a real or fancied necessity, the utmost care should be exercised in handling the coal so as to prevent breakage.

Many mines are using "degradation screens" to take out the fine pieces of coal made during screening. These are placed just before the loading boom, so that the coal as loaded is practically free from undersize. Degradation during transit can not be avoided, but care can be exercised at the point of delivery. All excess handling should be eliminated and coal should not be discharged into empty hoppers or bins unless necessary. If it can fall on a bed of coal in the bin breakage will not be so great. The pitch of chutes should not be so steep as to give a high velocity to the coal, for the impact will cause breakage.

Storage of Coal

But brief reference can be made to this phase of the subject. In general it may be said that sized coal is the only kind that should be put in storage piles, and it should be handled so as to prevent as much breakage as possible. Strong coals are better than friable ones for breakage is much less. Run of mine or screenings are considerable risk if stored, particularly if piled higher than 10 or 12 ft.

The common belief is that high sulphur coals cannot be stored successfully. This opinion will probably continue to prevail, although experiment has shown that pyritic sulphur is not the main cause of spontaneous combustion, but it is very likely true that high sulphur coals can be stored successfully if proper attention is given to sizing and piling. Adequate air circulation must take place throughout the pile to carry off the heat generated by the slow oxidation of the coal.

Particular care should be taken in the location of the bin in which the regular supply of coal is placed. Many fires have started because the bin was close to a source of heat—the base of a chimney, a steam pipe, or the like.

What Kind of Coal?

A plant should first determine what kind of coal and what size is best adapted to its requirements. The particular coal can then be selected on the basis of the best performance for the minimum cost. Clean, well-prepared coal, low in ash and sulphur and high in heating value is, of course, the ideal. No freight charges are paid on worthless material, the fuel value and efficiency of the coal is higher, less ash means a saving in the handling and disposal of the ashes, and probably less clinkering trouble due to the lower amount of ash. The fusibility of the ash is a point which should not be neglected, particularly where forced draft is used and the boiler run at high rating. In such cases coals having an ash with a very high fusion point must be chosen.

In any event, the criterion in selecting coals is the most power per dollar. Needless and whimsical specifications prove tremendously expensive. A low ash, high fusion point coal may command a higher price and take a higher freight rate than a medium ash with medium fusion point which can be obtained nearer home. If the cheaper coal can be used efficiently, there is no reason for paying a premium for the higher grade coal. Everything being equal, of course, the best prepared coal of the proper kind should be selected, one which will yield the most energy for the lowest cost.

Experiments in France have shown that creosoted fir poles are the most durable means of carrying electric wires. Fir is better than pine, and the creosoting approximately doubles the life of the poles, making it 12 to 14 yr. The poles are rapidly oven dried to a point where cracks or splits that might develop by weathering appear. Poles are then placed in a tank and treated with creosote under 20 to 25 lb. pressure so that the wood is impregnated through the cracks to the heart of the poles. These poles have a lower conductivity than those untreated, and can even be used without serious loss of energy during dry weather and when current is kept on only during working hours by attaching wires direct to the poles without the use of insulators. This applies, of course, only to low-voltage work.

Simple Maintenance Record

SYSTEM FOR RECORDING SERVICE RENDERED BY AND UPKEEP EXPENSE OF POWER PLANT EQUIPMENT. BY HUGH R. CARR

IN ALL large power plants, and in the power plants of some of the leading industrial establishments, a very complete operating record is kept. Except for these, it seems as if everyone else has entirely neglected this important matter. Probably the greatest reason for this is that the large plants have better facilities for the tabulation of the data taken from the plant. The writer has noticed that the system used for keeping the records in the big plants can be run only by an accountant. In the small plant, the engineer has to do without an accountant and he has neither the time nor the inclination to take care of any complicated records.

Being aware of the conditions outlined above and being particularly interested in boiler room problems, the writer has developed a fairly simple system of record keeping which can be applied, with some modification, to the whole power plant. It does not take into account interest, depreciation, or any of the other fixed charges, but simply records the service and maintenance. It is best adapted to the plant having a timekeeper and storekeeper or both incorporated in one man.

Does each machine do its share of the work and what does it cost to keep it doing that? This is the big question in the small plant. Fuel economy is generally not a criterion and, as long as the operation is not wasteful of fuel, therefore the questions of reliability and maintenance costs are the most important.

For the purpose of illustration, we will consider as an example a small boiler room producing an average of about 700 b.hp. This boiler house contains three boilers set over automatic stokers, two forced draft blowers driven by steam turbines, two engines for driving the stokers, one feed water heater, three flow meters for measuring boiler feed water, one draft regulator, two feed water pumps and drive, and one coal and ash conveyor. The high pressure piping, low pressure piping, and the general structure of the building will also be taken into consideration. This will make 31 items in all, each boiler, furnace, stoker, flow-meter, and soot blower installation per boiler being taken separately. Many other subdivisions might also be taken, such as the separation of feed water regulators being taken separate from the boilers, etc. For simplicity this will not be done, as such things as feed water regulators can be considered as part of the boilers and such things as draft gages as part of the furnace or stokers, according to where they are connected.

APPARATUS Stoker MACHINE No. 3 SIZE 32-39.4 sq. ft. MANUFACTURER —— DATE Aug 1922

DATE	NAME OR MATERIAL	MATERIAL No. PIECES	MATERIAL TOTAL WT.	HOURS LABOR	RATE OR COST	TOTAL COST MATERIAL	TOTAL COST LABOR
17	Peter Green			2½	65		1.62
18	Dump Tender	6	180	2	2.00	12.00	
18	Samuel Jones			1	55		.440
18	Peter Green			1	65		.520
19	John Parker			1	55		.440
19	Peter Green			6	65		3.90
19	Am Boy	1	185	3	2.00	2.00	
20	John Parker			3	55		1.65
20	Peter Green			½	65		.33
26	Peter Green			½	65		.32
TOTALS		7	365	31½		30.00	21.82

DATE	FLOW METER AT MIDNIGHT	HOURS OF SERVICE IN	HOURS OF SERVICE OUT	OPERATING PERCENT RATING
1	25705			
1	5107	24		
2	7190	24		
3	25887.0	24		
4	3550	24		
5	4955	12	12	
6	4985	24	24	
7	6006	16	8	
8	6066	24		
9	25971.37	24		
10	6023	24		
11	7009	24		
12	7990	24		
13	26027.72	24		
14	370	24		
15	744	24	16½	
16	749	24	24	
17	749	24	24	
18	749	24	24	
19	749	24	24	
20	780	24	24	
21	781	24	24	
22	831	24	9½	
23	26122.15	24		
24	508	24		
25	779	24		
26	26229.26	24		
27	2112	24		
28	26259.05	24		
29				
30				
31				
		558	249	1400

FIG. 1. TYPICAL MONTHLY RECORD OF UNIT EQUIPMENT

For the purpose of illustration, we will consider as an example a small boiler room producing an average of about 700 b.hp. This boiler house contains three boilers set over automatic stokers, two forced draft blowers driven by steam turbines, two engines for driving the stokers, one feed water heater, three flow meters for measuring boiler feed water, one draft regulator, two feed water pumps and drive, and one coal and ash conveyor. The high pressure piping, low pressure piping, and the general structure of the building will also be taken into consideration. This will make 31 items in all, each boiler, furnace, stoker, flow-meter, and soot blower installation per boiler being taken separately. Many other subdivisions might also be taken, such as the separation of feed water regulators being taken separate from the boilers, etc. For simplicity this will not be done, as such things as feed water regulators can be considered as part of the boilers and such things as draft gages as part of the furnace or stokers, according to where they are connected.

The simplicity of any system of records depends upon the making of that record with the facilities at hand and it is with this idea in view that the idea of using the storekeeper, timekeeper, or both, for keeping the record is used. Each man connected with the maintenance force, when he makes out his daily time card (if no card is now made out and turned into a timekeeper of some kind, some arrangement should be made to do so), places thereon the time in hours spent on each machine worked on throughout the day. This is on what the labor in maintenance will be based. In like manner, a requisition will be marked by the storekeeper, or his equivalent, with the cost and weight of that material. This requisition will be used as the base for the material maintenance record.

Each machine will have a page in a loose leaf book for the purpose, which page should be similar to that shown in Fig. 1. The storekeepers fill in daily from the time slips and requisitions the time and expense put on each machine or other part of the boiler room. This when totaled up for a given time, shows the maintenance for that time but not for a given amount of service.

In order to have a record of maintenance compared to service, it is also necessary to keep a record of the hours of service and if possible, in the case of boilers, furnaces or stokers, the water evaporated by the boilers or the coal fed to the boilers or both. Such information is generally available and can be put in as has been done in Fig. 1.

A monthly record of the total of the various single records is desirable and the totals of this will indicate the showing made for the month. Figure 2 is an example of a month covering the plant outlined above. These monthly summaries can be totaled up into yearly summaries and summaries for longer periods. Of course, the longer the period covered by a summary, the more operating and other information can be secured. Several additional items might appear on a record covering considerable time due to additions and replacements. Each new machine should be given a new number so that it will not be confused with the machine it replaces.

Let us consider the plant taken as an example. Figure 1 shows the record for stoker number three for the month of February, during which time repairs were made. On the dates Feb. 5 to 7 inclusive, the fire was probably banked for some reason and the boiler off the line. On the 16th, the boiler was taken off the line for general overhauling. The stoker, naturally, was gone over at this time also. The time spent on the stoker and the material used are recorded for this period. Before starting again, the boiler was refilled and it can be seen that the flow meter moved slightly. This movement is marked so as to be corrected for at the end of the month. From this evaporation data, the average load is calculated at the end of the month, in the example above being equal to 140 per cent of boiler rating.

The example of the monthly summation, such as shown in Fig. 2, shows how the data on the individual records of the machines can be summed up and maintenance figures calculated. The column "unit years" is the first which must be calculated and depends upon the time of service for the month and the overload on the machine (in the case of boiler, furnace, stoker, etc.). The unit year is the part of a year of continuous service, at full load only, to which the actual time of service is equivalent, the overload being taken into consideration. It will be seen that the unit year for a period of several months is equal to the unit year arrived at by the summation of the unit years of all those months. The total cost of maintenance for a year divided by the unit years of operation for that year gives the cost of maintenance per year in the same manner that the monthly cost divided by the unit year for that month estimates the cost per year. Naturally, the monthly estimate of yearly cost will vary much more from month to month than the yearly estimate will vary from year to year. Mathematically the unit year is equal to:

hours in service $\times$ per cent rating $\div$ 100 $\div$ 8760

The material cost, material weight, labor hours, and labor cost columns are also transferred from the individual records, but the last three columns in Fig. 2 are computed by dividing the weight, hours or cost by the value of the unit year. As indicated in Fig. 2, the maintenance is reported very high on some of the apparatus

FOR THE PERIOD FROM Feb. 1st TO 28th INCLUSIVE 1922

No.	APPARATUS	SIZE	HOURS IN SERVICE	PERCENT RATING	UNIT YEARS	MATERIAL COST	MATERIAL WEIGHT	LABOR HOURS	LABOR COST	MAINTENANCE PER UNIT YEAR WEIGHT	MAINTENANCE PER UNIT YEAR HOURS	MAINTENANCE PER UNIT YEAR TOT. COST
1	Boiler	250 H.P.	458	140	.0733	9.00	18#	7.0	46.68	249.5	95.2	479.00
2	Furnace		458	140	.0733	34.50	4506	7.5	49.75	6140.00	1026	10998.00
3	Stoker	394 0"	458	140	.0733	39.00	365	36½	241.21	4978.0	498	7478.00
4	Flow Meter		458		.0824							
5	Soot Blower		458	140	.0733			2	1.10		27½	150.00
6	Boiler	250 H.P.	672	136	.1045							
7	Furnace		672	136	.1045							
8	Stoker	394 0"	672	136	.1045							
9	Flow Meter		672		.0770			½	3.3		6½	9.30
10	Soot Blower		672	136	.1045							
11	Boiler	250 H.P.	208	143	.0339							
12	Furnace		208	143	.0339	.75	10	1	.65	29.5	29½	41.30
13	Stoker	394 0"	208	143	.0339	20.10	190	5	2.75	5600	1471½	67200
14	Flow Meter		208		.0237	.50	2	4	2.60	8½	17	131.0
15	Soot Blower		208	143	.0339							
16	Stoker Engine	12 H.P.	358		.0410							
17	Stoker Engine	12 H.P.	145		.0127			7½	2.28		590	1790.50
18	Blower	12000 C.F.M.	302		.0345							
19	Blower Turbine	20 H.P.	302		.0345							
20	Blower	12000 C.F.M.	371		.0424							
21	Blower Turbine	20 H.P.	371		.0424							
22	Feed Pump	100 G.P.M.	354		.0405	3.00	3	4	2.60	74	99	1356.00
23	Feed Pump Turbine	15 H.P.	354		.0405	3.50	3½	5	3.25	86½	123½	1670.0
24	Feed Pump	100 G.P.M.	319		.0365							
25	Feed Pump Turbine	15 H.P.	319		.0365							
26	Feed Water Heater	100 G.P.M.	637		.0728	1.25	10.0	9½	2.47	1370	62	51.20
27	Steam Pressure Regulator		672		.0768							
28	Ash and Coal Conveyor		252		.0287	2.00	40	3	1.75	1390	105	1495.00
29	High Pressure Piping		672		.0768							
30	Structure of Building		672		.0768	7.28	90	10½	5.78	1170	137	1690.00
31	Low Pressure Piping		672		.0768							
32	Meter + Arms (replaces no 17)		169		.0192	1.25	10½	1.2	7.20	5760	660	4640.00

FIG. 2. MONTHLY SUMMARY RECORD OF BOILER AND AUXILIARIES

for the month. This does not necessarily mean that the maintenance is high. Take the stoker, No. 3, for example. If this machine runs the two following months continuously and without repair, the unit year would then be, say, 0.2873 with no additional time and expense for repair and the estimate would then be 1270 lb., 127 hr. and $190.50 per year.

Modifications of the system outlined above are operating successfully. Some engineers prefer to take the apparatus in general classes instead of individually, that is, keep a record of all the boilers as a single unit, all the stokers as a single unit, etc. This is more simple, but also has obvious disadvantages. The individual record has, to the writer's knowledge, been carried by one very large corporation to the extent of embracing all of their machines in all of their shops and power houses. This particular corporation has a brass numbered plate screwed to each machine and the machines are identified by these numbers. Another common modification is that of keeping a record of cost only, eliminating the record of hours and weight of repair material; but it can be seen that such a record is incomplete when comparison is wished to be made with some other plant having a different wage scale and material cost. Of course comparison with other plants and also one size machine with another must also be made on a basis of capacity. Some values of capacity sometimes used for this work are: installed boiler horsepower, installed grate area, tons of coal burned, million pounds of water evaporated, etc.

The benefits derived from keeping such a set of records are many. Among the most important are: the ease with which one machine may be compared with another of the same kind; the simplicity with which such things as special baffles, various grades of stoker iron, furnace materials, etc., may be tested; the load under which some of the apparatus will operate with the lowest maintenance; and many others.

Burning Low Grade Fuel at West Point

Forced Draft Chain Grate Stokers Increase Steam Generating Efficiency

PRIOR to 1916, the power plant of the U. S. Military Academy at West Point, N. Y., had hand-fired boiler furnaces only, but at that time two new boilers were installed and these were equipped with Coxe chain grate stokers which are divided into four sections for the control of the forced draft. These grates were designed for No. 3 buckwheat coal and since they were installed considerable experimental work has been done with this low grade fuel. As a result of these experiments, the remaining four boilers were equipped last year with Illinois chain grate stokers of the forced draft type. The plant efficiency has been increased 15 to 17 per cent by these changes over results secured by hand firing.

The load on this plant, which fluctuates considerably, consists of some power, but principally heat, both exhaust and live steam being used about the campus; hot water and refrigeration are also furnished. The power load in the engine room consists of three Rice & Sargent engines direct connected to General Electric direct current generators. Two of these units are tandem compound, each rated at 400 kw. and the third is simple, rated at 200 kw.

Each of the six boilers in the plant is rated at 440 hp. and works under a pressure of 140 lb. They are Babcock & Wilcox, three-drum type boilers having a width inside the setting of 12½ ft. and a length of 24 ft.

In order to install the new stokers, experience had demonstrated the advisability of lowering the floor 2 ft. to give more combustion space under the boiler than was available with the old furnaces. Some difficulty was at first experienced in securing proper combustion with the low grade anthracite coal used; but with a change in the design of the arch to that shown in the cross-section, ignition, volatilization and complete combustion troubles have been eliminated.

One of the distinctive features of the Illinois stokers is the provision for igniting the coal. Under the front of the fuel bed, as will be noted in the drawing, is a tuyere which is connected directly to the smokestack which has a draft of 1⅛ in. and thus draws hot furnace gases down through the bed of green coal as it leaves the hopper, heating it up and drawing off the free moisture so that when the coal passes over the next tuyere, which supplies it with air, ignition occurs without delay.

FIG. 1. WEST POINT'S POWER PLANT OVER RAILWAY TUNNEL

Forced draft is supplied to all the furnaces through a wind tunnel with ducts leading to the wind boxes along the side of each stoker to which the tuyeres are connected. The air pressure in the wind box varies with the load carried, but averages around 4½ in. of water, the pressures in the tuyeres being individually controlled by manually operated dampers, the last two sections being used only at times of heavy loads, thus under ordinary conditions confining combustion to the section beneath the arch. Draft in the furnace is maintained automatically at 0.07 in. and at the damper it ranges from 0.25 to 0.3 in. under hand control. The natural draft is induced by a radial brick stack 135 ft. high by 9 ft. in diameter, so built into the architecture of the building that it can hardly be observed.

It is customary to operate the boilers at 160 per cent of their rating, but at times the load is increased to 225 per cent. The thickness of the fuel bed ordinarily car-

ried ranges from 4½ to 5 in. The travel of the grate is regulated by means of a variable speed motor drive; at ordinary load it is about 32 ft. per hour, increasing to 38 ft. at 225 per cent boiler rating; the rate of combustion averages about 35 lb., but at high rating runs

FIG. 2. BOILER ROOM VIEW, NEW STOKERS IN FOREGROUND

up to 55 lb. per sq. ft. of grate surface per hour. The time required for doubling the rating of the boilers has been as low as 3 min.

Furnace temperature under the arch averages about 2850 deg. F., and at 100 per cent rating the stack temperature is 510 deg. F., at 165 per cent, 570 deg. and at 225 per cent 635 deg. F. It was formerly the practice to use the hand steam lance once a day for removing soot from the tubes and in three weeks the stack temperature would increase to 720 deg. F. with an average load of 160 per cent. Diamond soot blowers are now installed which are used once in each 8-hr. watch with considerable reduction in stack temperature as is shown by the recording pyrometers.

As a check on combustion, a Uehling CO_2 recorder is provided which shows an average of 12 to 13 per cent of CO_2 in the stack gases, although the boiler settings are not in the best condition.

As previously stated, the coal used in this plant is small size anthracite, about the order of No. 3 buckwheat which goes through a 3/16 and over a 3/32-in. screen. It has a heat value averaging 12,200 B.t.u. per lb. and an ash content of 17 per cent, though deliveries have been received containing 35 per cent of ash, yet no difficulty has been experienced in burning this coal due to high ash, and notwithstanding the high furnace temperatures the ash does not fuse into clinkers. The efficiency obtained from one of these boilers under test was 73.4 per cent and the water evaporated per pound of fuel was 8.36 lb.

Coal comes to the plant in hopper bottom cars, being delivered by gravity to a belt conveyor which discharges to a bucket elevator and this in turn to a distributing belt conveyor over a 500-T. bunker directly over the firing aisle which discharges through chutes to the stoker hoppers.

Ashes falling to the pit beneath the rear of the grate are scraped forward to an American steam jet conveyor which discharges to the river bank. Accumulation back of the bridgewall is removed every two weeks. The ashes are used for roads, sidewalks, filling, etc.

Excellent surface water is available for boiler feed purposes and it is not treated except for filtering and the addition of a little graphite in the boiler. Once a year the lower rows of tubes are cleaned by running an air driven turbine through them.

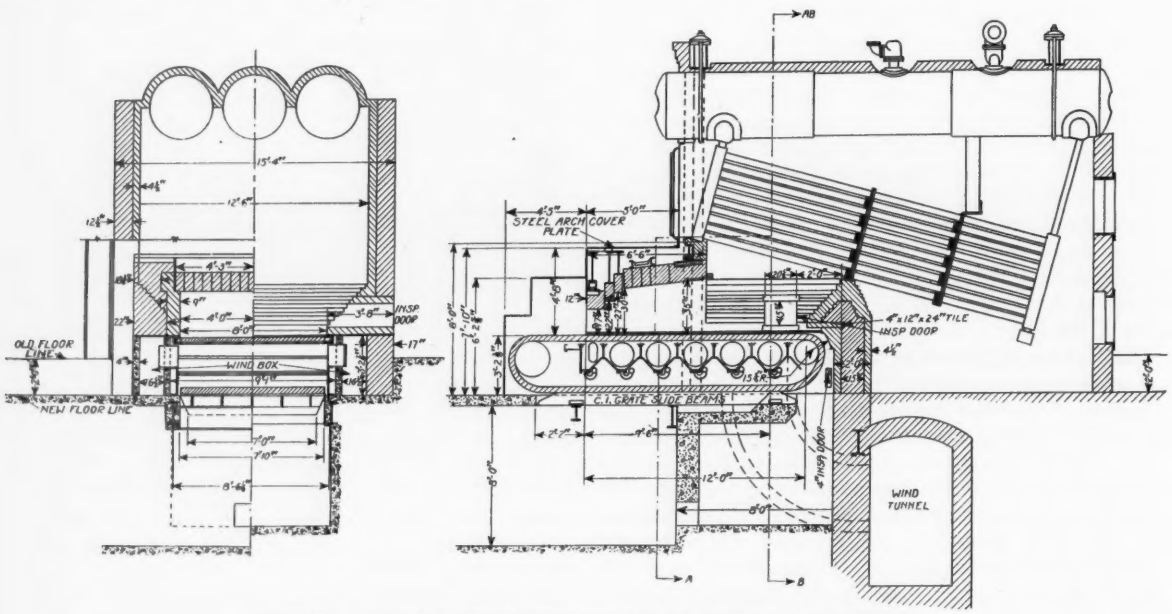


FIG. 3. SECTIONAL VIEWS THROUGH BOILER SETTING AND STOKER

Considerable pioneer work was necessary in this plant to secure the results which have been obtained and credit is due P. J. Bryant, the chief engineer of the plant, for his unceasing efforts extending over a number of years, not only to modernize an old plant, but to make it one of the first to use successfully unmixed low grade anthracite coal on a chain grate stoker.

Oil Engine Hints

WATER AND OIL COOLING; ALTITUDE AND POWER; WATER PUMPS; EFFECTS OF OVERHEATING; BROKEN PISTON RINGS. BY BERT BARE

THE QUESTION of cooling, water in some cases, oil in cases where this is used for piston cooling, may be summed up in the principle of allowing the engine to run in as warm a condition as is reasonably safe to avoid detrimental heating of any part. The oil engine is primarily a heat engine and it is just as important to keep the cylinders warm as it is to keep the heads warm in the case of low compression engines. Some will object and say that, if the cylinders are kept warm, the incoming air will be heated and thus reduce the weight of air admitted per stroke. Theoretically this is true, but the difference is small and the advantage of a warm cylinder in promoting and maintaining perfect combustion, and in this way greater economy in the use of fuel, will more than balance the loss in power.

COOLING WATER

IN MOST cases of water cooling the cool water should be allowed to enter the engine at the lowest point, which will be at the bottom of the cylinder cooling space. The hot water should leave at the highest point to prevent air or steam pockets, hence the outlet should be from the top of the cylinder head. Ample cooling water pumps should be supplied by the manufacturer in the first place. In some places where the engines have been developed in localities where the water is cold, the supply of water has not proved sufficient when the engines have been run in the tropics, and they overheated. Where this trouble has been found the addition of auxiliary pumping facilities has helped out.

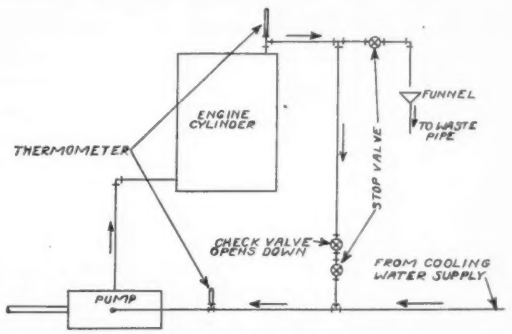
Where the engine has been fitted with ample size pumps, the supply of water will, at times, be found too great for best running conditions. It will be well, therefore, to connect the piping with a bypass from the "overboard" to the cooling water pump suction. This can best be done by connecting a pressure check valve in that part of the line leading from the outlet to the suction side of the pump and placing a throttling valve in the "overboard" part of the line so that any desired regulation can be obtained. In this way the temperature of the incoming water can be kept at the desired degrees.

This suggests the use of thermometers in the "overboard" and the suction lines, which is done by using tee connections instead of ells, and screwing mercury cups into the tops of the tees for the thermometers, in the usual manner. In stationary plants, a popular connection for the "overboard" is to lead separate pipes from the cylinder heads to a funnel. As the oiler passes this common funnel, he runs his hand along the top of the funnel and can detect any unduly heated stream. Thermometers, one of which should be provided for each cylinder, will give quicker signs of trouble as a smaller variation of temperature will be more easily noted. The water discharge temperature should not be higher than 125 to 150 deg., at or near sea level, in any case. At higher altitudes the temperature should be correspondingly lowered.

In this connection it might be stated that an engine which develops, say, 1500 hp. at sea level will develop 1100 hp. at an elevation of 6000 ft. The compression space, however, will need alteration because the heat of compression is dependent on the ratio of compression and not on absolute pressure alone.

Heat developed in an engine is more of a factor than the pressures used. It is the temperature and not the pressure that causes the burning of parts and the disintegration of the materials of which the parts are made. Efficiency, and therefore fuel consumption, is also a function of the pressure ratios so that at higher altitudes the engine will show as good a fuel economy as at lower levels, but will work with lower pressures. The loss will be in power only.

In the case of low compression engines where it is particularly desirable to have the head as hot as possible and where it is thought best to have the cylinder cooler, a bypass can be fitted so that water can flow from the



BYPASS CONNECTION FROM OUTLET TO COOLING WATER PUMP

junction of the cylinder and head. Placing the pressure check at this point and by having the throttling valve regulate the flow through the head, the head can be kept as warm as desired.

In the low compression engines where a "hot bulb" is used one of the troubles has been that of cracked heads. In a great many cases where this has happened, a survey of the cause will show that the water jacket space was so shaped as to cause imperfect casting. There would be metal where there should have been water. This has been the cause of trouble with some of the first designs of heads by some manufacturers. Now heads are made so that there will be ample core space and ample provision for the supporting of cores and for cleaning the castings after founding. These same holes will be found of value in cleaning the heads of sediment that will settle from the cooling water. Keeping these castings clean so that the cooling action of the water can be fully utilized is of paramount importance and where the ports are of ample size there is no excuse for not keeping the heads up to their best possible condition.

CLEAN WATER SUPPLY. WATER PUMPS

CYLINDERS should also be fitted with ample ports for cleaning. In marine installations where the boat is being run in shallow water, the engineer will have to watch carefully for sand in the engine. In this case, a tank where the water will have a chance to slow down and drop some of the silt that it is carrying will

be quite a help in keeping the engine in the best condition. High-speed pumps should be avoided. They are noisy in the first place and will not stand up to the work in the second place. The main trouble with high-speed pumps will be found in the valves pounding themselves to pieces.

In stationary installations the water supply coming from the regular plant supply need not be taken care of by the engine pump. It will be necessary, of course, to start the water flowing through the engine before the engine is started up and it is desirable to keep the cooling water running for a few minutes after the engine has been shut down. Just as there is heat left in an oil-fired boiler after the oil has been shut off, so is there heat left in an oil engine after the engine has been shut down and it is best to keep the water circulating to take care of this heat.

In marine jobs it is well to arrange for an auxiliary water supply to the engine to supplement the supply from the pumps on the engine. This can be done, if necessary, by connecting the fire pump so that it can be used to pump water through the engine before the engine pump gets going. In this way, also, cooling water can be continued after the engine has been shut down. By this arrangement it will also be possible to continue running the engine, if it is found necessary temporarily to shut down the engine water supply pumps. Lloyds requires the circulating pump to be an integral part of the main engine.

Where the piston is water-cooled, it is best to allow the piston to run as warm as possible without causing the formation of steam in the piston cooling chamber. Since it has been stated that the best running conditions favor a warm engine, it would be best to have the piston as warm as it can safely be kept. As long as there is contact of water with the piston, it is cool enough; but where steam forms, the pressure caused would seriously affect the continuity of flow and destroy the cooling water circulation. This cooling water must be taken care of in the most efficient manner so as absolutely to prevent any water from getting into the lubricating oiling system. This is vitally important in marine installations where salt water is used for piston cooling, as a small amount of salt water will ruin the highly polished bearing surfaces in no time. It has been found necessary where water has been found in the lubricating system to overhaul the engine completely.

Overheating

Where oil is used for piston cooling, it is necessary to run the oil as cool as possible to prevent the breaking up of the oil and the formation of carbon deposit under the top of the piston. As has been pointed out before, carbon is a good insulator and where carbon forms on the piston, the cooling effect is not abated and the piston heats up and expands until it seizes and stops the engine.

If it is noted in time that a piston is giving trouble in this way, the load on that cylinder should be "cut out" and the engine should be kept turning over, if possible. The oil feeding to the cylinder through the mechanical lubricators should be immediately increased to the maximum and, if necessary, hand feeding should be resorted to in order to let the piston work itself into condition. It has also been found to be an advantage to increase the flow of cooling water through the water jacket to help cool the piston. If the engine were to be stopped while the piston were in this condition, it would freeze and the engine would have to be taken down and the piston pulled out.

After the piston has been worked in again and the cause of the heating been found and remedied the cylinder can be put back in working condition and carefully watched for awhile. If the piston should seize, the cylinder would be scored and in drawing the piston, further scoring would in all probability occur. If the scoring is not so bad but that it can be used without replacement with a new cylinder liner, a good stoning will usually put the cylinder and piston in running condition. The amount of scoring that has occurred will determine how well the engine will now run.

Where a piston has been overheated trouble with the piston rings may be looked for. The heat will have burned out the lubricating oil and the rings will tend to stick and destroy effective compression. The rings may also be found to be broken. The first ring will generally be in trouble most of the time as it is the first one to take up the line of defense. If this ring is the only one affected and the others are in good condition, let well enough alone. It means that the first ring is amply performing its function of holding back the heat and there are enough other rings to take care of the compression feature properly.

Broken piston rings are not always due to the heat troubles. The design of the rings may be at fault. Where there is excessive ring breakage due to no apparent cause, the ring itself is probably at fault. If the ring is broken into a number of small pieces about equal in size, the spring in the ring is too great and a new ring with less spring should be tried out. Where the engine is of the trunk piston type and where the wristpin has been removed, care should be taken not to force the piston out of round when the wristpin is driven back in place. The pin after being forced into place should be tapped back far enough so that calipers show that the diameter along the wristpin is equal to that at right angles to the wristpin.

In a survey of the Salt Lake City smoke problem engineers of the Bureau of Mines found that about 27 per cent of the smoke made in the city was from residences. As the most obvious way of eliminating the domestic smoke nuisance is to provide smokeless fuel for these consumers, the bureau conducted an investigation regarding the feasibility of establishing a local supply of coke to take care of domestic heating requirements. The bureau found that the installation of a by-product plant of sufficient size to supply the entire domestic demand of Salt Lake City for coke fuel is not economically feasible unless municipal legislation prohibiting the production of smoke is obtained. By education and legislation consumers must be induced to pay $3 more per ton for smokeless fuel than for the ordinary bituminous coal in order to make the carbonization plant a success. While the coke and by-products of a low temperature carbonization plant would probably find a readier market than those of a standard high temperature plant, neither plant would be a commercial success without protective legislation.

Power From Refuse in Britain

PRODUCER GAS MADE FROM FACTORY AND DUST-BIN REFUSE USED IN GAS ENGINES AND BOILER FURNACES. BY C. H. S. TUPHOLME

PART of the campaign for fuel economy in Britain has resolved itself into the use of various types of refuse for producing gas to be used in internal combustion engines and for firing steam-generating boilers. It is recognized that the aggregate annual value of vegetable and other refuse collected, and afterwards wasted or destroyed without performing any useful work, is almost beyond computation. It is to enable part of this potential source of power to be turned to useful account that the Wells combined destructor and gas producer has been placed on the market.

Superintendents of cleansing departments, and others responsible for refuse removal in counties and municipalities, have already achieved much in the treatment of household refuse by recovering therefrom material that can be utilized in one form or another. Thus cinders, partly spent coal, etc. (fuel often of a higher calorific value than gas coke), approximating in weight to 30 per cent of the refuse collected, have been recovered and put to useful work. Paper and rags are reclaimed, disinfected and disposed of at favorable prices, tins are sorted out and in some cases pressed, baled and sold for remelting either before or after the tin has been recovered. There are many other ways in which household refuse is turned to useful account, some crude, while others are more elaborate.

The composition of dry dust-bin refuse varies with the season and the locality. Thus trade refuse will obviously differ as the industries vary in the particular area. It may, however, be assumed that the composition of dry dust-bin refuse approximates very nearly to the following analysis:

Fuel, consisting of cinders, partly spent coal, etc.	30—35%
Dust	30—40%
Debris, such as bottles, china, shale, bricks, etc.	10—12%
Tins	1%
Light debris or tailings, made up of rags, paper, vegetable matter, and light trade refuse	10—12%

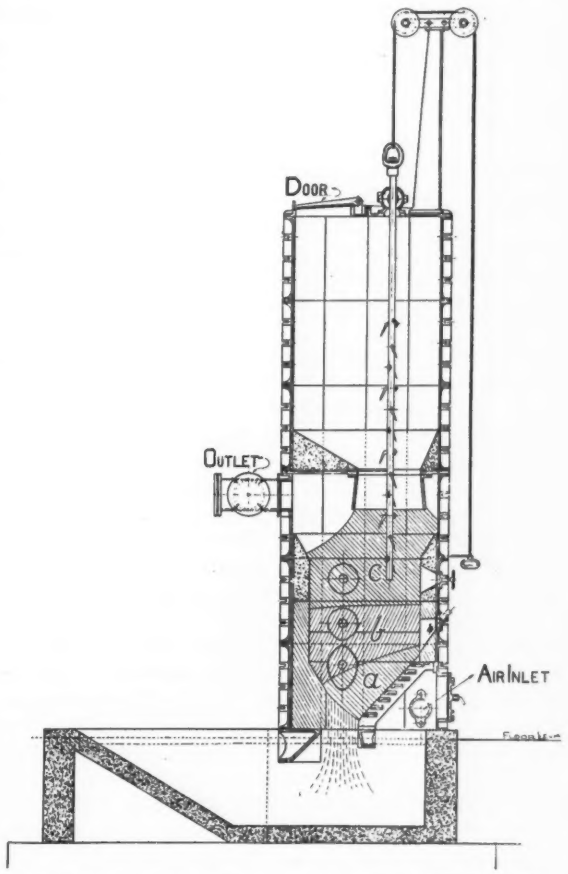
It is from cinders, partly spent coal, etc., also from the light debris or tailings that "Vegablegas," as the product of the Wells producer is called, is obtained.

From the average composition of dust-bin refuse it will be understood that 40 to 47 per cent of the refuse collected will be available for conversion into useful gas. In a community of, say, 8000 people, dry dust-bin refuse would be about 5 T. per day. There would be thus available:

Fuel, consisting of cinders, etc. (35 cwt. for conversion to gas)	35%	35 cwt.
Dust (of manurial value)	40%	40 cwt.
Debris, bottles, china, etc	12%	12 cwt.
Tins	1%	1 cwt.
Tailings or light debris (10-12 cwt. for conversion to gas)	12%	12 cwt.

In the investigations of John Wells he ascertained that the power available from the gasification of 1 T. of dry wood refuse was 750 hp.-hr. The destruction and conversion of 1 T. of fuel, tailings and light debris to vegeblegas would yield 500 to 600 hp.-hr., so that in the community referred to above, of 8000 people, there would be available approximately 40—47 cwt. of refuse per day, equal in value to 2-7/20 of 500—600, say 1170 to 1400 hp.-hr. The average calorific value of one cubic foot of gas produced from anthracite is 140 B.t.u. The average calorific value of one cubic foot of vegablegas is 130—135 B.t.u.

This difference in calorific value is largely made good due to the fact that if vegablegas is used explosively, as in a suction gas engine, less air is required with gas



WELLS VEGABLEGAS PRODUCER AND REFUSE DESTRUCTOR

of such lower calorific value, so that the final value of the charge, i. e., the number of heat units, remains practically the same, and there is therefore no appreciable variation in the horsepower of any given gas engine, whether the fuel used is anthracite, cinders, partly spent coal, tailings or light debris. This statement is supported by the report of the Inter-Departmental Committee on the employment of gas as a source of power, appointed by the Government in 1917. An extract from this report says:

"A typical suction gas will contain 140 B.t.u. (gross) per cubic foot, but it will require only 1.33 volumes of

air to one of gas for its combustion. Each 100 cu. in. of such combustible gas delivered to the induction pipe of the engine will, notwithstanding the poorness of the gas itself, contain a total of 3.5 B.t.u. The apparently weak gas is thus seen to be a satisfactory fuel."

It was repeatedly demonstrated, between the years 1917 and 1919 and subsequently thereto, and the results claimed have been consistently borne out by further experience, that using vegetable fuel by direct gasification in one stage the Wells destructor and producer can be relied upon to give a gas having a calorific value between 130 and 140 B.t.u. per cu. ft.

Vegablegas is broadly applicable to two main purposes, viz.:

1. Providing gas for internal combustion engines of most types.

2. Providing gas for heating purposes, including application to existing boiler plant.

The chief objections that have been raised against the use of waste vegetable matter or house refuse in the place of more costly fuels have been:

1. The physical characteristics of the fuel, i. e., its bulk.

2. The chemical properties of the fuel; high percentage of ash, high moisture content, and the production of tars.

Experience has shown that the design of the Wells producer and auxiliaries can operate commercially with vegetable fuels, and that the principal difficulties inherent to such a method have been overcome, viz.:

1. The problem of construction of furnace and hopper to admit fuel being fed sufficiently fast to keep the fuel at the required level in the producer.

2. The effective cleaning of the gas from all traces of tarry matter so that the gas would be suitable for internal combustion engines.

The presence of tars in vegablegas and all similar producer gas renders it essential that a reliable means is necessary to clean the gas before it reaches the engine. The Wells construction, together with the rotary tar extractor and scrubbers, deals with the cleansing problem in an effective manner. It provides a combined furnace and gas producer which will operate satisfactorily with the lower grades of vegetable refuse fuels ordinarily obtained as a waste product in agricultural districts, such as undergrowth, scrub, etc., and in manufacturing areas, house refuse, trade waste and similar matter.

The manufacturers of the Wells producer have adopted interchangeable rectangular cast-iron plates to build up the producer, also for the wet and dry scrubbers, which facilitates production and the problems of handling, erection and replacement. A feature of the design is that the destructor and producer, as also the subsidiary plant, is rectangular in plan.

The elevation herewith shows in section a standard destructor and gas producer for the destruction and gasification of refuse fuel. The principles upon which the plant operates are similar to the more orthodox types of gas producers using higher grades of fuel.

The sequence of reactions within the destructor producer are as follows:

There are three zones, *a*, *b*, and *c*.

a is the combustion or high temperature zone.

b is the conversion zone.

c is the distillation zone.

Zone *c*: This zone is a distillation or carbonizing zone in which the vegetable matter or house refuse is converted into charcoal.

Zone *b*: In this zone the charcoal formed in zone *c* is maintained at a temperature a little lower than that in zone *a*. As the gases formed in zone *a*, more especially the carbon dioxide, resulting from combustion of the carbon, pass over the hot charcoal in zone *b*, the latter absorbs part of the oxygen and the carbon dioxide is converted into carbon monoxide, and in such form passes to zone *c*, and from there to the scrubbers or boilers.

Zone *a*: In this zone the charcoal descending from zone *b* is burned entirely, and provides the heat necessary to maintain the producer in operation. In this zone a large proportion of moisture is admitted below the grates and is converted into hydrogen and oxygen by contact with the incandescent carbon. The hydrogen passes up through the producer, forming one of the most valuable of the heat-producing constituents of vegablegas. The oxygen is taken up in assisting combustion of the fuel.

An average composition of vegablegas by volume analyzes out as follows: CO_2, 3.5 per cent; CO, 23.0; O, 1.9; H, 13.0; CH_4, 2.1; and N, 56.5 per cent.

The chemical composition of charcoal is very much the same as that of anthracite, but its physical properties are quite different. Charcoal differs from anthracite in that it is of lower specific gravity and is more readily combustible, responding quickly to the varying demands of a gas engine.

The Hardening by Steam of Concrete Construction Elements

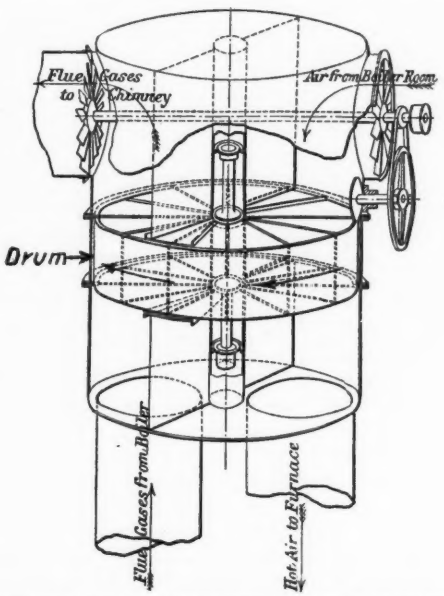
M. SALIGER, professor at the Ecole Technique Superieure at Vienna, has been granted a patent for a process of hardening concrete blocks rapidly, submitting cement to the influence of high-pressure steam which hardens the cement in a few hours throughout the whole mass. The hardening is equivalent to that which is given on the surface only by exposure to the air for several weeks. The resistance of the cement, consequently of the concrete, is increased, so that in order to get a given resistance a poorer mixture can be used. The cooking is done by loading the blocks on wagons which are run into brick tunnels. The blocks are allowed 3 or 4 hr. for setting in the air, after which they remain in the tunnels, which are filled with steam at from 120 to 130 lb. per sq. in. for 12 hr. J. H. BLAKEY.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has recently shipped to the Pacific Gas & Electric Co. for its Mt. Shasta development what is believed to be the largest high tension oil circuit breaker ever built. The breakers were built for the 220,000-v. Mt. Shasta development and are for use of a 220,000-v. system having a solidly grounded neutral. The breaker is good for a 350-kv. wet test. The gross shipping weight of the breaker, including oil, is 90,000 lb. The breaker requires 2000 gal. of oil for each pole. The height from the ground to the top of the bushing is 17 ft. 6¼ in., and the long diameter of the tank is 8 ft. while its short diameter is 5 ft. 8 in.

Air Preheater for Boiler Furnaces

MECHANICAL TRANSFER OF HEAT FROM FLUE GASES TO THE INCOMING AIR IS ACCOMPLISHED IN HEATER OF NOVEL DESIGN

IT IS GENERALLY conceded that the greatest source of loss incident to the operation of a steam boiler is the quantity of heat carried to waste by the flue gases. Modern practice demands that the amount of excess air used be reduced to a practical minimum, but this has been accompanied by an increase in flue gas temperature so that the saving in lost heat has not been all that might be expected. Various devices have been brought out to reduce the flue temperature, such as economizers and air preheaters, but their installation has not been universal on account of the high initial cost investment and high maintenance charge. Air preheating has been accomplished in two ways. In steel plants it is common practice to pass the high temperature flue gases and incoming air alternately through



DIAGRAMMATIC ARRANGEMENT OF AIR PREHEATER

a brick checkerwork. In this way the brick, heated by the gases, subsequently gives up this heat to the incoming air. For boiler furnaces where the exit temperature is not as high, this method has proved impractical and it has been customary to transmit heat from the waste gases to the fresh air, through thin metallic surfaces separating the air passages from the flues. Under these circumstances, the heat transfer is not great, as the temperature difference is small and the surfaces quickly become covered with soot and other insulating material.

An air preheater of Swedish design described in a recent issue of Engineering (London), is designed to transfer heat continuously in a mechanical way from one medium to the other. Referring to the accompanying figure, fresh air is drawn by a fan into the upper portion of a vertical cylindrical casing which is divided into two parts by a vertical partition. Air is confined to one side of the partition and passes downward to a similar semicircular chamber through the body of a porous cylindrical drum. The flue gases from the boiler traverse the other half of the apparatus in the reverse direction, entering the lower chamber and passing upward through the drum to the upper compartment where they are exhausted to the stack by another fan.

The porous drum is kept in a state of continual slow rotation so that the portion heated by the flue gases is constantly passing to the other side of the apparatus where it gives up its heat to the cold air. Similarly, of course, the cool part of the drum is continually returning to be reheated by the flue gases. Deposits of soot have no serious effect on the apparatus, as there is no transfer of heat through the metal. Any deposits that do accumulate may be readily blown out by means of a steam jet.

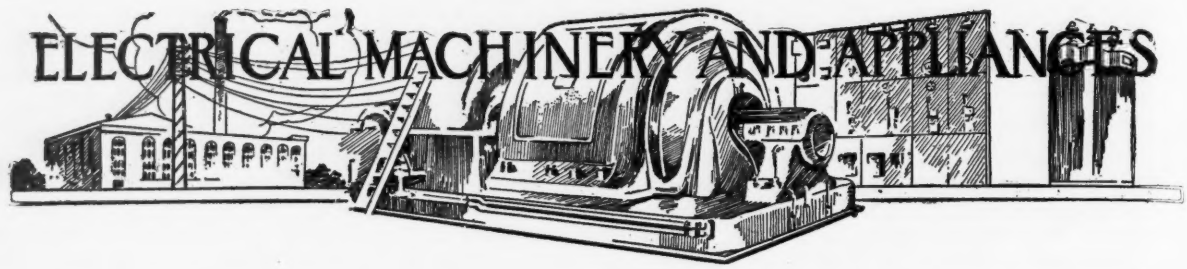
The porous drum is built of thin sheet steel and divided into sectors by radial plates which serve as stiffening spokes. Each sector is packed with a number of thin sheet steel plates which are separated by small channel strips welded in place. The construction is such as to offer a minimum of resistance to the passage of gas, yet brings both gas and air into intimate contact with a large absorbing surface.

Comparative tests on a horizontal return tubular boiler, with and without this preheater, showed a substantial increase in efficiency by preheating the air in this manner. The overall boiler and furnace efficiency was increased from 66.9 to 77.6 per cent, and the flue gas lost was reduced from 15.3— to 5.8 per cent. Air for combustion was heated from 84— to 275 deg. F. by the preheater and the flue gases were, at the same time, reduced from 432 to 253 deg. F., a temperature but infrequently attained in boiler practice.

FEDERATED AMERICAN Engineering Societies has been studying the question of two-shift and three-shift day for continuous industries and reports of the investigators will be presented to the executive board at the meeting in Boston on September 8 and 9. These reports will discuss the practicability of abolishing the 12-hr. shift and especially will consider the change in operations needed for the steel industry. Other industries which have been investigated are glass, cement, lime, brick, chemicals, petroleum, vegetable oils, paper, flour, rubber, mining, the public utilities and personal service, such as hotels and apartments.

The Boston meeting of the executive board will also consider the question of reorganization of governmental departments and the proposed Department of Public Works, to include reforestation, flood control and water supply. The federation has recently admitted to membership the Engineers' Club of Columbus, Ohio, and will act upon the application of the Engineers' Club of Louisville, Ky., at the Boston meeting.

IN THE course of the experiments being conducted by the Bureau of Mines at Pittsburgh, Pa., looking toward the development of grates and furnaces to enable lignite char to be used for domestic purposes, a sheet iron grate for use in base burner stoves has been designed which permits lignite char to be burned in such stoves in place of anthracite. The development is of interest in connection with the problem of commercial utilization of the vast lignite deposits of the Northwest.



Locating and Repairing Alternating Current Motor Troubles

HINTS ON THE PRACTICAL METHODS OF LOCATING FAULTS IN INDUCTION MOTORS. BY MARIN PHILLIPS

LOCATING trouble in electrical machinery is largely a matter of experience. The greater a man's experience in this line the easier will it be for him to determine and locate the cause of failure in a given case. However, as in other lines, there are certain guide posts which if recognized will lead the inexperienced trouble shooter along the right road to the source of trouble.

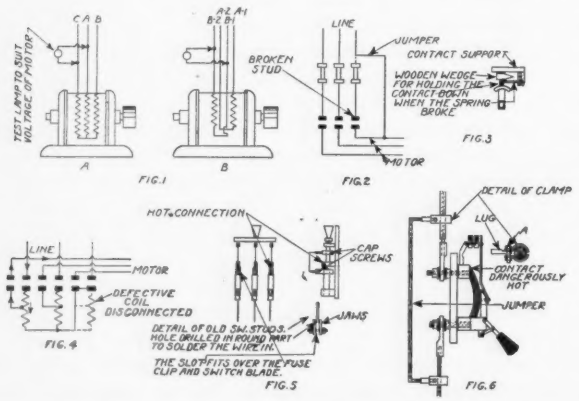


FIG. 1. A. TEST FOR SINGLE-PHASE OPERATION OF A THREE PHASE MOTOR. B. TEST FOR SINGLE-PHASE OPERATION OF A TWO-PHASE MOTOR

FIG. 2. QUICK METHOD OF OVERCOMING TROUBLE DUE TO A BROKEN STUD

FIG. 3. METHOD OF REPAIRING CONTACT BY MEANS OF A WOOD WEDGE

FIG. 4. METHOD OF MAKING TEMPORARY REPAIR BY CUTTING OUT AUTO TRANSFORMER COIL

FIG. 5. JUMPER MADE FROM TWO OLD SWITCH JAWS

FIG. 6. ANOTHER IMPROVISED JUMPER

For the purpose of acquainting the engineer or electrician who has not been fortunate enough to have had a broad experience with these guide posts, the following hints are given.

For the purpose of analyzing the most important troubles that occur in every-day practice, alternating current motors may be divided, conveniently, according to type, into four main classifications, as follows:

1. The squirrel cage motor } 2 and 3-phase.
2. The wound rotor motor }
3. The split phase motor } single-phase
4. The repulsion motor }

In alternating current motors the stationary member which is connected to the line is called the stator and the rotating member, the rotor. The squirrel cage type of motor is the simplest of all motors, the rotor being made up by placing copper bars in the slots and then connecting their ends to copper rings.

In this article, troubles encountered with the squirrel-cage type of motor will be discussed. The following troubles, which also apply to the other types of motors, are the ones most commonly met with; blown fuse, open circuits, short circuits, grounds, and burned out bearings. The latter condition may be due to the use of dirty oil, belt too tight or, if direct connected, the machine which it is connected to may have considerable end thrust and thus grind out the bearing, in which case the shaft should be provided with a thrust collar.

Suppose in the case of a squirrel-cage motor equipped with no voltage release and overload relays, the motor shows signs of trouble by stopping at frequent intervals. To locate the trouble first feel of the motor and if it has a higher temperature than normally allowed, it may be overloaded or one of the bearings may have given way allowing the rotor to rub on the stator which would result in overloading the motor; this, of course, would operate the overload relay and trip out the starter. The clearance between the rotor and stator should, therefore, be checked with a thickness gage.

After going over the bearings and if they are found to be all right, test the motor to see if it is grounded, which is best done by testing with a magneto that will ring through quite a high resistance. A test lamp is not very good for testing where a motor is setting on an iron or steel platform, or where the frame is in contact with any piping, for if a wire was touched to the frame of the motor and the other wire was grounded, as is usually the case, a short circuit would be the result and blow the fuse. To test for a ground, put one of the test leads on the frame of motor, and touch the other one to the frame as a check to see if good contact is made with the frame; if so, the bell will ring when the magnet is turned. One of the test leads is then touched to the motor leads; if the bell rings and the motor is connected to the starting box, disconnect the line wires from the motor and ring it out again for a ground. If in the latter test the motor is tested free of grounds, it is evident that the ground is in the starting box or in the wires leading to the motor. These will then have to be disconnected and each one of them tested separately.

In testing for an open circuit, put one of the test leads on one of the motor leads, and touch each of the other leads with the other test lead. No ring would indicate an open circuit.

The next thing to do would be to see if the motor was running single-phase; that is, if one wire is disconnected from the line at some point. In case of a blown fuse or a broken wire, the motor would not start up alone, unless it was in the running side of the starting box. Suppose, for example, that the contacts and all connections are in good condition on the starting side, and that one of the contacts on the running side is not touching, then the motor would have all three phases to start up with; but as soon as the starter was moved to the running position, the motor would be running single-phase. This would cause a much heavier current to flow in the two wires that are in good condition, causing the overload relays to operate or the fuses to blow. The capacity of the fuses should be 25 per cent greater than the full load ampere capacity of the motor. In testing to find out whether the motor is running single-phase, a test lamp is touched to the leads, first on lead "A" and "B," Fig. 1, then on "A" and "C," and if a bright light was obtained on both connections the wiring is good up to the motor. Suppose, however, that the light was only about one-half as bright on leads "A" and "C" as it was on "A" and "B," this would indicate that something was wrong with the running side of the starting box, and that the motor was running single-phase. Of course, something might be wrong with the winding inside of the motor, in which case the test just described would not indicate it. In some motors, it is easy to tell by the sound whether they are running single-phase or not by the way they howl, and sometimes it can be detected by feeling of the wires leading to the motor. If it is running single-phase and the wires are not too large, two of them will be hot and the other cold.

To take another case, suppose that the motor gave trouble by stopping frequently and that inspection showed the temperature to be normal; then one of the following conditions may be causing the trouble. The relays may be out of adjustment or there may not be sufficient oil in them. There may be poor contact in the tripping attachment that opens the no-voltage release coil, allowing it to drop and trip out the starting box, or vibration may be causing the contact to open. Again, the no-voltage release coil may have a portion of the turns short-circuited, which will reduce the holding power of it, or a poor contact in the starting box or fuse block may make and break the circuit every now and then on account of vibration.

Sometimes a motor will heat up due to rotor trouble. This can be checked by noticing the speed of the motor. If the frequency is up to 25 or 60 cycles, whichever the case may be, and the motor is running below full load speed, and it is known that the motor is not considerably overloaded, it will indicate that the rotor needs an overhauling.

The motor may be heating up, operating at a lower voltage than its rating, and may fail to start. First test the fuses and replace any that are blown, then place the starter on the starting position. If motor fails to start, release starter, test the fuses again; if found all right, hang the test lamps on two of the wires leading to the motor, and place the starter in the starting position and note how the lights burn. Now release the starter and place one of the test leads on the other wire leading to the motor, and again place the starter in the starting position and note how the lamps burn. If the same as before, the starter is in good condition; but if a different brightness of light is obtained there is an open circuit in the starter.

The foregoing test is for a three-phase, three-wire starter. For a two-phase, four-wire starter the test lamps would be connected on to the two wires that correspond to the phase. Suppose the starter tested out all right, then move the test lamps to the terminals of the motor and repeat the above test. If the lights have a different brightness on different wires, then there is an open circuit between the motor and starter, but if the lights are the same the starter and line wires are free from open circuits. In making the foregoing test, it is very important not to leave the starter in the starting position any longer than it takes for the lights to light up. If the lights have a different brightness on different wires, then there is an open circuit between the motor and starter, but if the lights are the same the starter and line wires are free from open circuits. In making the foregoing test, it is very important not to leave the starter in the starting position any longer than it takes for the lights to light up. If left on for any length of time, the auto transformer coils may be damaged.

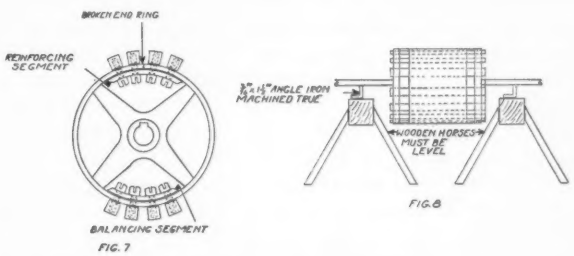


FIG. 7. MAKING REPAIRS TO A BROKEN END RING
FIG. 8. METHOD OF BALANCING ROTOR

If when a motor is started the fuses blow out at the instant the starter is placed in the starting position, the trouble may be caused by short circuit or ground in the starter, motor, or the wires leading to the motor. To test for it, pull the switch so as to have the fuse clips and starter dead, then put one of the test wires on a fuse clip, and the other on the metal cover of the starter, first scraping the paint and dirt off a small spot so as to have a good contact for the test wire, then place the starter in the starting position and turn the magneto. If it rings, it will indicate a ground in the starter on the wiring leading to the motor, or the motor itself. To locate which one the ground is in, disconnect the wires leading to the motor at the starting box, then ring out the starter; if no ground is indicated, it is either in the wire or the motor. Again disconnect the wires at the motor and ring each one out separately.

In testing for the short circuit the only part that can be tested out with the magneto is the wires from the starting box to the motor, which may be done by dis-

connecting them at the motor and letting the starter be in the off position. Then one side of the no-voltage release coil will have to be disconnected, which may be done by raising the plunger on one of the relays, if they are used, so as to open the circuit, or if a push button is used for stopping, it may be blocked open. Then touch the test leads to two of the wires at a time, and if a ring is obtained it will indicate a short circuit, and in order to locate it, it will be necessary to disconnect the wires from the starter and test each one separately. If it is desired to test out the wires for a broken one, fasten them together at one end and connect the test leads on the other end to two of the wires at a time and turn the magneto. If it should ring on two of the wires, then when one of the test leads were changed to another wire the magneto failed to ring, it would indicate one of the wires broken. If it failed to ring on any of the wires, it would indicate that two of them were broken.

The reason that a short circuit cannot be tested for in the preceding manner, in the starting box and motor, is because the auto transformers are connected together, and so is the winding in the motor, and any attempt to ring them out for short circuit would give misleading results, as the magneto would ring through the windings, indicating a short circuit, although there might not be one. Supposing a ground was located in the starting box, it would probably be an easy matter to locate and repair it, if it were not in the auto transformer coils. If the starting box is equipped with three auto transformer coils, disconnect the star connection and test each coil separately. Then connect up the two good ones as shown in Fig. 4, and tape up each end of the coil; that is, cut out, so that it cannot become short-circuited or grounded. Then when time permits, it may be repaired; but if the coal is burned and damaged it will have to be cut off the iron, for if it is not, the short-circuited turns will draw such a heavy current from the line that it will blow the fuses. If the coil appears to be in good condition it should be saved as explained above, but in case it is left on the iron and gives trouble while starting, it will have to be removed. If there are only two coils in the starting box and one of them gives trouble, it will be necessary to change them, or the starting box, and put up a good one. The starting box may be blowing the fuses when it is shifted over to the running position, because the motor did not start while in the starting position, or the starter was shifted too quickly from the starting to the running position, not giving the motor sufficient time to come up to speed before shifting to the running position. There might also be a ground as mentioned before, or a short or open circuit if the motor failed to start, which would be tested for in the manner already described, or the motor may run a little while before blowing the fuses, in which case it might be running single-phase.

The starting boxes for motors equipped with auto transformers are provided with taps for obtaining different starting voltages, and the one that will just start the motor is the one to select. In case of trouble where the motor must be placed back into service as quickly as possible, some kind of temporary repair that will enable the motor or starting box to be put back in service with as little time lost as possible, will be welcomed. For instance, in the starting box a stud or contact may break or burn off, and it would take an hour to repair it correctly. To avoid loss of time, a jumper can be put on, or some other temporary repair made in a few minutes, and the permanent repair made when it can be spared from service. Figure 2 shows how the wire was jumped around a broken stud in about 10 min. that would have taken 2 hr. to repair the stud. Figure 3 shows how a wooden wedge was driven between the contact and its support when the spring was broken and the contact would not touch. Many expensive shut-downs can be avoided, if the starting boxes are given a good inspection, renewing the burnt contacts at least once every two months. But if the starting box is in severe service, that is, starting and stopping very often, it should be inspected at least once a month. It is very important to have spare parts on hand to replace worn-out parts such as contacts, studs, supporting block for the contacts, no voltage release coil and a spare set of auto-transformer coils. As for the motors, spare bearings should be kept on hand, spare brushes for the slip ring and repulsion types.

Figure 4 shows how a temporary repair was made by cutting out one of the auto-transformer coils and Fig. 5 shows how a jumper was made from two old switch jaws and applied to a switch to relieve a hot contact of the load to prevent a shut-down on an important drive. In Fig. 6 is shown the manner in which a jumper was made out of a length of 300,000-c.m. wire, with lugs soldered on each end, and bolted to a clamp that was made out of ⅛ by 3-in. flat copper bus bar. The clamps were formed to shape around a pipe so that the top and bottom halves would come together when the machine bolt "a" was tightened up. The jumper was made to carry the current around one pole of a three-pole circuit breaker that was becoming dangerously hot. Figure 7 shows how a repair was made to a broken end ring and in Fig. 8 the method of balancing the rotor after the repair was made to the broken ring. The piece of copper bar fastened over the break with machine screws and lock washers put the rotor out of balance. The rotor was placed on the balancing horses and a piece of copper, a little larger than the one already over the break, was applied opposite the break and a little filed off, until it balanced.

Construction of Rheostats with the Minimum of Resistant Metal

By J. H. Blakey

LA REVUE Generale de l'Electricite of October 29 publishes a long analysis, accompanied by numerous diagrams, of an article by M. Richter in the Elektrotechnische Zeitschrift of March 10, in which the author proposes to substitute for the old method of regulation by variation of the length of resistances, combinations of resistances in parallel or in series-parallel, in such a way as to utilize constantly the whole of the radiant surfaces of the resistances. Similarly, for triphase currents he employs a star-triangle combination.

The same method can be generalized and extended to voltage regulation by devising coil elements instead of rheostat elements and in working upon induction or transformer coils. The article contains extensive calculations.

Parallel Operation of Commutating Pole Machines

A Review of the Principles Involved in Paralleling Machines with Particular Reference to Those of the Commutating Pole Type. By C. B. Hathaway

DIRECT-current motors and generators have been operated in parallel for years, and new units are being successfully paralleled every day. But each time the machines do not parallel successfully the same questions are always asked, and are always answered the same way. Therefore, the subject is reviewed here with the hope that those interested in this work may see the solution from a little different angle, and that, perhaps, it may be a little clearer to them.

For successful parallel operation of electrical machines, each individual unit must tend to throw the load onto the other units. In other words, each unit must have a shirking characteristic. This is fundamental. In the case of a generator this means that the voltage across each unit must fall with an increase of load. Thus, if one generator started to take more than its share of the load, its voltage would fall, due to the RI drop in the armature, etc. The current would go to the other generator, because current flows between the point of the greatest difference in voltage. The voltage across the second generator would then fall. The voltage would rise across the first generator and it would again take its share of the load. This tendency for each machine to throw the load onto the other provides a stable condition for parallel operation.

The shunt generator has this shirking characteristic at its terminals and consequently it is very well suited for parallel operation. This can be seen readily by referring to Fig. 1, the lowest curve of which represents the terminal voltage plotted against the load current. The voltage drop a is the RI drop of the armature. The drop b is due to the distortion of the field flux. The drop c is due to the reductions in excitation, which in turn is caused by the drop in voltage across the field winding.

It must be emphasized that it is not sufficient that the machines have only a slightly shirking characteristic—they must have a decidedly drooping curve. The importance of this is evident from Fig. 2. In the upper pair of curves (slightly drooping characteristic) the load is divided in the ratio of ab to ac; while in the lower pair, with more droop, the ratio is a'b' to a'c', giving decidedly more uniform division of load. The droop of the lower pair is exaggerated, but it illustrates the point.

There are several ways in which a generator can be given a drooping characteristic:

1. The brushes can be shifted forward, if the commutation permits.

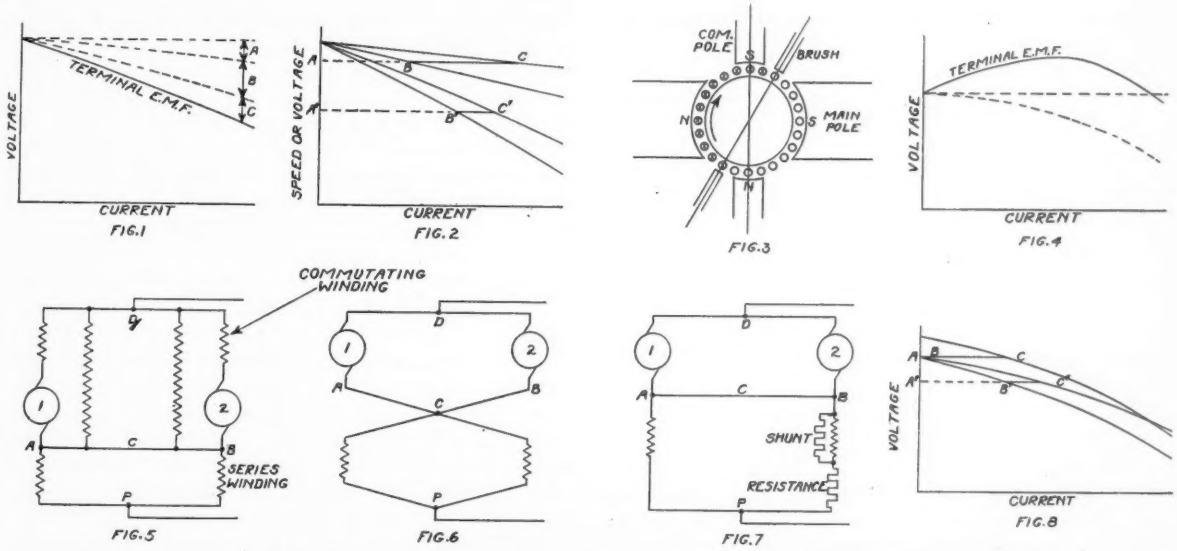


FIG. 1. SHUNT GENERATOR CHARACTERISTICS. FIG. 2. DIVISION OF LOAD BETWEEN TWO PAIRS OF SHUNT GENERATORS. FIG. 3. EFFECT OF SHIFTING BRUSHES ON GENERATOR FIELD STRENGTH. FIG. 4. COMPOUND GENERATOR CHARACTERISTICS. FIG. 5. EQUALIZER CONNECTION. FIG. 6. CONNECTIONS EQUIVALENT TO FIG. 5. FIG. 7. PERMISSIBLE SHUNTING OF SERIES FIELD. FIG. 8. DIVISION OF GENERATOR LOADS

2. A few turns of differential series winding may be wound on the main field poles.

3. An external resistance may be inserted in the armature circuit.

4. Use an under-compensated commutating field.

In Fig. 3 it can be seen that if the generator brushes are shifted in the direction of rotation, the south commutating pole is on the same side of the brushes as the north main pole. That is, the south commutating pole is working against the north main pole, which gives the machine a drooping curve. On the other hand, shifting the brushes against the direction of rotation tends to give the machine a rising characteristic.

If a few turns of differential series are wound on the main poles an increase in load weakens the main poles, thereby causing the terminal voltage to drop.

An external resistance added to the armature circuit simply causes a greater RI drop with an increase in load.

The effect of the commutating field on the characteristic curve is really of more interest to the designer than it is to the man who actually operates the machines. It is usually very inconvenient to change the air-gap in a machine after it has been set up. However, it may be well to state the effects obtained by this change. If the strength of the commutating pole is greater than that just necessary to neutralize the reactance voltage of the short-circuited coil being commutated, the machine is said to be over compensated. If the strength is not quite enough it is said to be under compensated. In the case of the generator, over compensation strengthens the main pole, giving a compounding effect with increase of load. Under compensation weakens the main pole, giving the generator a drooping characteristic. Changes of this kind are liable to impair the commutation.

The speed regulation of the prime mover is also important in the division of the load. A decrease in speed of one machine has the same effect as if the field was weakened; in either case the generated voltage will

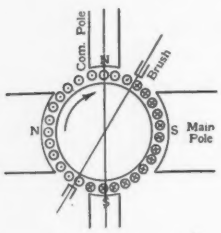


FIG. 9

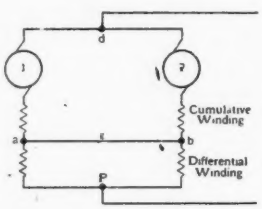


FIG. 10

FIG. 9. EFFECT OF SHIFTING BRUSHES ON MOTOR-FIELD STRENGTH

FIG. 10. CONNECTION FOR PARALLELING SHUNT GENERATORS

fall. A drooping speed characteristic of the prime mover is not undesirable, but all the prime movers should have the same speed regulation.

Exactly the same laws govern the parallel operation of compound generators as shunt generators. The terminal characteristic of the compound generator is shown by the upper curve in Fig. 4. The voltage rises with increase of load usually through the working range of the machine. The hump in this curve is more pronounced in some machines than in others. Also in some machines the voltage may rise very rapidly at first, and then rise at a slower rate. From the fundamental condition given in the first part of this discussion, the compound generator cannot be paralleled at its terminals. Therefore, this type of generator must be paralleled at a point where it does have a shirking characteristic. At its armature terminals (including the commutating field winding, of course) it has the same characteristic as the shunt generator. At this point, with an increase of current the voltage tends to fall for the same reasons as discussed in the case of the shunt generator. One side of the armature of each machine is connected by an equalizer, shown as acb in Fig. 5. The action is the same as if the equalizer was arranged as shown in Fig. 6. In either diagram the points cd are the actual points of paralleling.

It is clear from Fig. 6 that the load current divides in the series fields in the inverse ratio of the resistance of these windings. Now with the load current constant, suppose that machine No. 2 tends to take more than its share of the load. The voltage from a to c through No. 2 machine will fall, due to the increase in the RI drop, etc., while the voltage from a to c through No. 1 machine will rise due to the light load. Since the current flows between the points of the highest voltage, it will immediately start to leave No. 2 and go to No. 1. A balance is quickly reached and the machines will continue to operate in parallel. During this action there has been no change in the current in the series fields, so there has been no change in voltage across either armature due to the compound winding.

It is evident that the equalizer must be a very low resistance conductor. It should contain no fuse, circuit breaker or other similar contact in its path.

If the series field resistances are not inversely proportional to the capacity of the generators, resistance should be added in series with the one that is low. Ordinary copper wire can be added as this resistance, as it is not essential that nickel-silver or other high resistance material be used, as is sometimes assumed.

If one of the generators operating in parallel is more heavily compounded than the other, it may be necessary to add so much resistance in its series field circuit that nearly all the load current will be diverted through the series field of the second machine and cause this winding to overheat. In order to avoid this, a shunt can be placed across the series winding of the first machine; but it should be clearly understood that a shunt placed across the series field of one machine, where two machines are operating in parallel with an equalizer, also shunts the series winding on the other and the desired division of load is not obtained. However, if a resistance is inserted in the series field circuit of one machine, as shown in Fig. 7, then one of the series windings may be shunted. In this way neither winding will be overloaded and the proper compounding can be secured.

From this discussion, it is evident that if the resistances of the leads between the point of equalization and the point of parallel connection at the switchboard are not equal, because the position of the generator requires a greater length of lead from one machine than from the other, these resistances must be made equal before the machines will divide their load equally. In other words, in Fig. 5 the total resistance between points aP and bP must be equal if the machines are to divide their loads equally. If the machines are of different capacities, these resistances should be inversely proportional to the capacities of the machines.

In paralleling generators it is essential to parallel them first at no load. This is the simplest and most logical procedure, and it will avoid trouble later. Once set at no load, the shunt field rheostats should not be changed after the load comes on. The reason for this can be seen from a study of Fig. 8. If the machines are set to divide the load equally at full load, as shown by the upper pair of curves which cross at full load, the no load voltages may be entirely different from each other. At about half load the division of load will

be ab and ac, that is one machine may be carrying almost the entire load, with the other practically idle. With a further decrease in load, the one machine will actually drive the other as a motor. If they are paralleled at no load they may divide the current at intermediate loads in some ratio such as a′b′ to a′c′ which is much more desirable than the first case.

Paralleling Motors

Two or more motors belted or geared to the same load present the same problem of parallel operation as do the generators, and the problem is solved in the same way. The same principles hold for motors in parallel. Fundamentally they must have the same speed regulation, and each motor should have a decidedly drooping speed characteristic. The cumulative compound or series motor is best suited for this work.

In the case of a motor, the effect of the commutating field is that over compensation tends to demagnetize the main poles, giving the machine a rising speed curve. Under compensation strengthens the main poles and gives the machine a drooping speed curve with increase in load.

Shifting the motor brushes also has the opposite effect of that of the generator. From Fig. 9 it is evident that if the brushes are shifted forward the commutating poles aid the main poles, increasing the counter e.m.f. This gives the effect of cumulative compounding, or a drooping speed curve. Shifting the brushes against the direction of rotation gives the effect of differential compounding. The effects of the commutating field and the shifting of the brushes on a motor are opposite from those produced in a generator because the current flows in the opposite direction in the armature and the commutating field.

Before paralleling the motors, the speed curves of each should be made to droop, and droop alike. If this cannot be secured by enough shifting of the brushes without sacrifice of commutation, series turns should be added on the main poles. If the drop in speed is not allowable for the application, the connection shown in Fig. 10 can be resorted to. Suppose that five turns of cumulative series were added to a shunt motor, and then five more turns wound in the opposite direction, with an equalizer connection as shown at ab. The actual point of paralleling would be ed which has the cumulative (drooping) characteristic desirable for parallel operation. Then outside of this are the number of differential turns. This restores the machine to its original shunt characteristic, with a small regulation. That is, as far as speed is concerned, the two windings would neutralize one another, producing no effect; but the motors would divide the load as if they were cumulatively compounded.

The cumulative and differential windings would be interchanged in the case of two generators with the same connections with equally good results. In this case the differential winding should be inside the point of paralleling ab and the cumulative winding outside.—The Electric Journal.

Chicago boiler settings for h.r.t. boilers call for a height from dead plate to shell as follows:

Shell Diam., In.....	84	78	72	66	60	54	48	42
Ht. to Shell, In.....	38	38	36	34	34	32	30	28

Pipe Bending Chart

By W. F. Schaphorst

Here is a chart that will be found valuable and convenient for determining the average radius of bend that should be given to common forms of pipe bends, numbers 1, 2, 3, and 4, as shown at the right, Column E.

Or, knowing the radius of bend, the size of pipe, and the form of bend, column D gives the expansion allowance of that bend.

For example, a 5-in. pipe was made to a radius of 40 in., the bend being a common U-bend as shown by No. 2 in column E. What expansion may be allowed?

The dotted line drawn across this chart shows how the chart is used. Run a straight line through the 5 column A and the 40 column B and locate the intersection with column C. Then from that point of intersection run over to the mark in column E opposite the

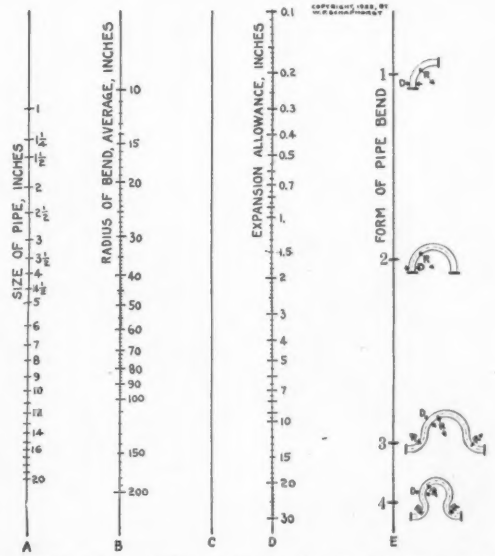


CHART FOR SOLVING EXPANSION BEND PROBLEMS

figure 2 and intersection through column D gives the answer as 1.5 in. expansion allowance.

Similarly if the expansion allowance is already known, if the form of bend is known, and if the size of pipe is known, the average radius to which the bend should be made may be determined in the same way. In other words, knowing any three of the four factors given in columns A, B, D and E, the fourth or unknown factor is easily determined by following the method as explained above.

This chart is based upon the following rules:

For Bend No. 1—Square the average radius of bend in inches and multiply by 0.0026 and then divide by the outside diameter of the pipe in inches.

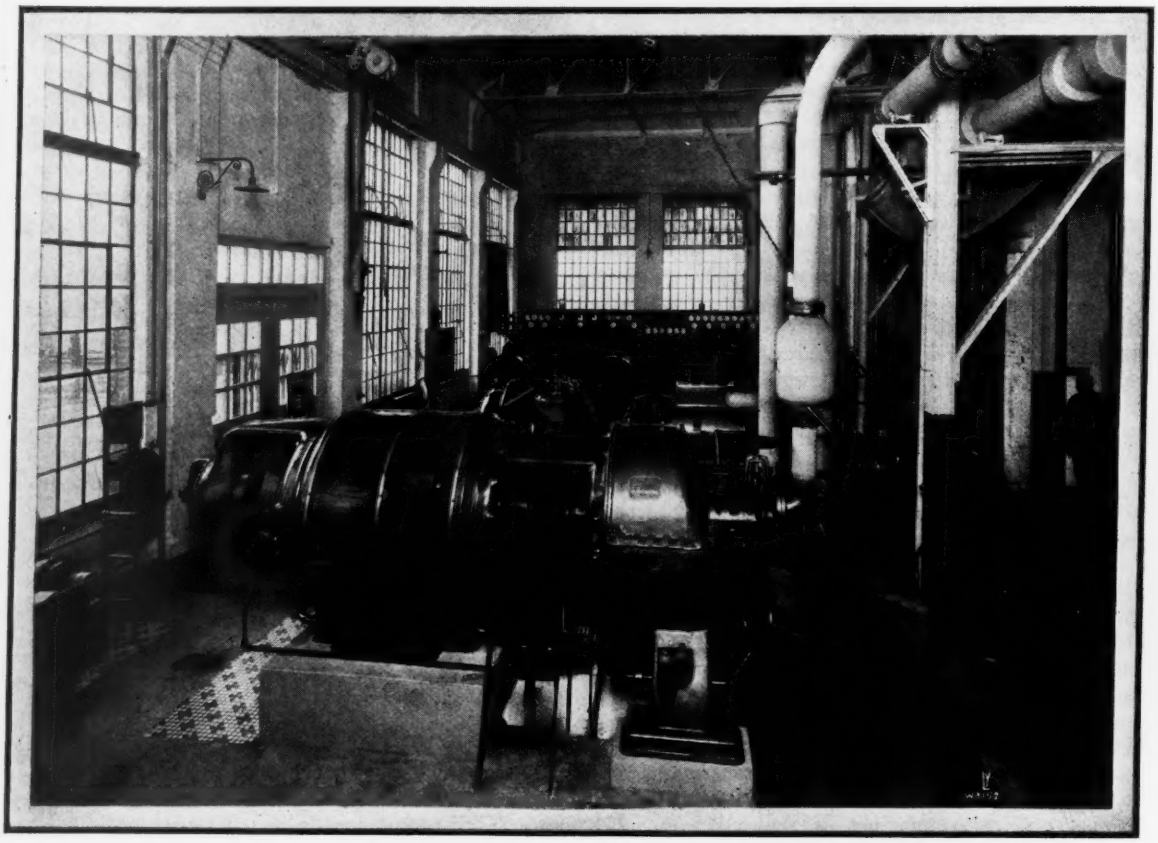
Bend No. 2—Same as No. 1, but use 0.0052 instead of 0.0026.

Bend No. 3—Same as No. 1, but use 0.0104.

Bend No. 4—Same as No. 1, but use 0.013.

In the chart, all of these operations are already performed—the radii are squared, exact outside pipe diameters are employed, and the proper factors are used.

Power for the Largest Paper Box Board Mill on the Pacific Coast



ONE OF THE largest and most important industries on the Pacific Coast is that devoted to the manufacture of paper box board. Among the numerous mills comprising this industry, the largest on the entire coast is the one operated by the Paraffine Companies, Inc., at Antioch, Calif.

This mill is supplied with steam and electricity by a modern power plant, a view of which is shown above. A peculiar feature of this plant and one that is clearly brought out in the photograph, is that the boilers are located in the same room with the turbines. This, of course, is made possible by the use of oil as fuel.

The boiler equipment consists of one 500-hp. Stirling, two 200-hp. B. & W. and four Franklin boilers, giving a total rated capacity of 1848 boiler horsepower. Two duplex oil pumps take suction through a 4-in. line from an underground oil storage tank, and deliver the oil to the burners under a pressure of 80 lb. Before entering the burners it is heated to 130 deg. F.

Electric current is generated by two turbine generating units, one a 600-kw. Curtis type machine and the other, a 600-kw. Westinghouse General Electric Parsons unit. Current is generated at 440 v. 60 cycles 3 phase. The turbines operated at 3600 r.p.m. with 150 lb. steam pressure. Exhaust steam is used in the board mill in drying the boxboard, and live steam is reduced to 40 lb. pressure for use in rotary digesters for preparing straw for strawboard.

Flow of Condensation in Return Pipes

FACTORS INVOLVED IN THE CORRECT DETERMINATION OF RETURN PIPE SIZES. BY R. V. FROST*

ANY CONSIDERATION of the action of return pipes resolves itself into two parts: Wet returns and dry returns. Wet and dry returns are not affected by the same conditions; wet returns having but one element, water, whose flow is determined by head or pressure and by friction; while dry returns have to do with two and sometimes three elements, water, air, and steam, all of which react to the impelling forces in different ways.

DRY RETURNS

WHEN THE radiation is first heating up, the maximum volume of condensation is encountered. The rate of flow is dependent largely upon the rate of admission of steam to the radiating surface, for when there is an ample supply of steam at the source, the steam supply pipes, if properly proportioned, are able to deliver, at the pressure differential, the full volume of steam that the radiator will hold, at a much faster rate than the radiator trap will permit the exit of air and water.

The velocity of air flow must be low in order not to require too great a pressure drop. If ¾ oz. pressure drop is allowed, the velocity in a 1½-in. pipe will be 20 ft. per sec.

This pressure drop would seem to be sufficiently low for the most extreme cases, since the resistance at the exit would be atmospheric or less, and pressure would be required only to overcome friction losses and to give velocity to the air flow. A velocity of 20 ft. per sec. as a maximum is undoubtedly below the point at which the air would pick up or crowd the water of condensation flowing at the bottom of the pipe.

The velocity of water flow in a dry return is caused by the slope or gradient of the pipe and is influenced but little, if any, by the pressure drop. Internal friction is the principal retardent to the water flow, and the slope must be such as to overcome or balance its resistance.

If steam is admitted to the return line, as is the case in the typical vapor system, the pipe capacity must be

DATA FOR DRY RETURN PIPES. CONDENSATION FILLING 3/16 OF THE PIPE AREA. GRADE 1 IN. IN 20 FT.

Pipe size	$a = \frac{3}{16}\frac{\pi d^2}{4} = 0.1475\,d^2$	$c = \frac{207.275}{1+\frac{0.465}{\sqrt{R}}}$	$\sqrt{R} = \sqrt{\frac{0.1475d^2}{1.13d}} = 0.361\sqrt{d}$	d = actual diam. of pipe in feet	Q = cu. ft per sec $= a\,c\sqrt{R\,s}$	Sq. ft. rad. $= 865000\,Q$	v = ft. per sec. $= c\sqrt{R\,s}$	Velocity ft. per min.	Free area $= \frac{13}{16}\frac{\pi d^2}{4} = 0.638d^2$	Total air volume at 3 cu. ft. per 100 sq. ft.	Air C.F.M. at 10 min. for total discharge	Velocity ft. per min. through free area
½	0.000398	31.2	0.0823	0.052	0.000066	57	0.166	10	0.001725	1.71	0.171	100
¾	0.000694	35.0	0.0945	0.0688	0.000148	128	0.213	13	0.00300	3.84	0.384	128
1	0.00112	38.7	0.1068	0.0873	0.000299	258	0.267	16	0.00485	7.75	0.775	160
1¼	0.00195	43.2	0.1222	0.115	0.000665	575	0.341	21	0.00843	17.25	1.725	205
1½	0.00266	45.0	0.1320	0.134	0.00102	885	0.384	23	0.0115	26.60	2.66	231
2	0.00435	50.5	0.1500	0.172	0.00213	1840	0.490	29	0.0188	55.25	5.525	294
2½	0.0062	53.9	0.1635	0.205	0.00353	3050	0.570	34	0.0268	91.50	9.150	340
3	0.0096	58.3	0.1820	0.255	0.00658	5700	0.685	41	0.0415	171.0	17.10	415
3½	0.0129	61.5	0.1960	0.296	0.01003	8700	0.780	47	0.0558	261.0	26.10	460
4	0.0165	64.5	0.2090	0.335	0.01435	12400	0.870	52	0.0715	372.0	37.20	520
5	0.0260	69.4	0.2340	0.420	0.02725	23600	1.05	63	0.1125	708.0	70.80	630

This condition causes the maximum exit of air at the time of maximum condensation. The return pipe must therefore be capable of handling the maximum of condensation and maximum volume of air at the same time.

The maximum air volume to be expelled from the radiation is equal to the internal volume of the radiation. By calculation it is found that a 1½-in. pipe has the greatest ratio of volume to heating surface of any of the commonly used types of radiation, this ratio being 3 cu. ft. per 100 sq. ft. of surface. This quantity is therefore taken as the unit of air flow. The rate of air emission from the radiator is subject to great variation, but as the pipe capacity must be sufficient for extreme cases, 10 min. is assumed a liberal allowance for the total emission of air from the radiator.

*Abstract of paper presented at the summer convention of the American Society of Heating and Ventilating Engineers at Buffalo and Detroit.

increased in proportion to the volume of steam admitted. The volume of steam should be treated as increased air volume, and the increase to the condensation allowed for by increasing the radiation condensation factor.

The flow of air and water in the return is usually in the same direction, but when the flow of the two elements is in opposite direction to one another, allowance must be made so that the air velocity can be reduced. What this velocity should be, is difficult to determine. As an assumption, however, this reduction can be placed at 25 per cent, or a velocity not to exceed 15 ft. per sec.

Restrictions in the return line, such as elbows, probably do not affect the velocity of water flow in the same manner as internal friction, but do affect the carrying capacity of the pipe, through the tendency to pile up the water at the turns, thus reducing the free area for the movement of air.

Factors Affecting Proportions of Return Pipes

From these conditions, the following factors affecting return pipe sizes are obtained:

1. Volume of condensation, to be stated in square feet of radiation.

2. Velocity of condensation flow, of which the following are sub-factors:

a. Area of the pipe.

b. The perimeter of the pipe in contact with the water.

c. The coefficient of friction for the material of the pipe.

d. The slope, expressed as a ratio of the height to the length.

3. The volume of air to be discharged, which resolves into three sub-factors:

a. Time allowance for discharge.

b. Velocity of air flow.

c. Free area of pipe for the passage of air.

In a dry return where but a portion of the area of the pipe is occupied by water, the frictional resistance is dependent upon the ratio of the cross-sectional area of the water in the pipe to the perimeter of that portion in contact with the water, i. e., the ratio of the wet area to the wet perimeter, the hydraulic radius.

Chezy's formula for flow takes into account all the factors affecting the flow of condensation in a dry return. This formula, in the usual form is expressed as

$$Q = a \times c \sqrt{rs}$$

Where Q is the discharge in cu. ft. per sec., a is the wet area in sq. ft., r, the hydraulic radius, s, the slope, expressed as a ratio of height to length, and c, a constant from Kutter's formula which is dependent upon the slope, the hydraulic radius, and a coefficient n for the roughness of the sides of the pipe.

$$c = [41.6 + 0.00281 \div s + 1.811 \div n] \div [1 + (41.6 + 0.00281 \div s) \times (n \div \sqrt{r})]$$

The value of n has been determined by experiment and varies from 0.010 for smooth iron pipe to 0.012 for cast-iron pipe and up to 0.017 for channels having walls of rabble or granite blocks.

In the absence of experimental data on the fullness of condensate flow in the return pipes, two values were assumed, ratio of wet area to total area ⅛ and ¼, finally 3/16 was decided upon as best fitting current practice. For an average grade of 1 in. in 20 ft., s = 0.004,17. Table I was worked up on this basis.

To consider the factors affecting the air flow, take a specific case. From Table I it is found that a 1¼-in. pipe will carry the condensation from 575 sq. ft. of radiation when flowing 3/16 full. The balance of the area of pipe, or free area for the flow of air is equal to $13/16 \times 0.7854\ d^2$, where d = 0.115 ft., has a value of 0.008,43 sq. ft. The volume of air from 575 sq. ft. of radiation, at the ratio of 3 cu. ft. per 100 sq. ft. of radiation, equals 17.3 cu. ft. If discharged in 10 min., the rate of flow is thus 0.0288 cu. ft. per sec., or a velocity through the free area of the pipe of 3.42 ft. per sec., or 205 ft. per min. Similarly, the result for a 2-in. pipe is a velocity of 4.9 ft. per sec. or 294 ft. per min., and for a 5-in. pipe, a velocity of 10.5 ft. per sec. or 630 ft. per min.

From these figures it is seen that the air velocity is much below the allowable limit of 20 ft. per sec. and it may be that the allowable limit that has been assumed is much too high. The sizes of returns as worked out on the 3/16 proportion are considered high by some authorities and low by others, but strike a fair average of what may be considered best practice. It is quite possible that the action of the water at the turns, in choking the free air passage, may be the cause for the required low air velocity, a point that can only be determined by experimental research.

If it is true that such low air velocities are necessary on account of the choking at the turns, then it is quite evident that by the use of long sweep fittings, this trouble could be largely removed, and as a result the capacities of the return lines somewhat increased.

Wet Returns

The Chezy formula is also used in hydraulic work for pipes running full, and it would seem that it could be adapted to wet returns as well, but conditions are not quite parallel. The formula is used in hydraulics when the velocity of flow is maintained by the slope, but since the flow in a wet return is actuated by a pressure head, although of necessity very small, the regular formula based on Bernoulli's theorem by Unwin and Weisbach and of the same form as the Babcock formula for the flow of steam, is the proper one to use.

A very convenient form for the purpose of computing a wet return is expressed by

$$d = 0.0226 \sqrt[5]{r^2 l}$$

where d is the diameter of pipe in in., r is the sq. ft. of radiation, and l is the length of pipe in feet.

So far dry and wet returns have been considered only in a horizontal position. Return risers can not be proportioned by the aid of either the Chezy or Unwin formula, but it is doubtful whether the flow of condensation in the riser need be taken into account, allowance being made for the passage of air only. Of course, if there are horizontal steps in the return, then the horizontal formula must be applied, but if proper allowance is made for the volume of air to be moved in the vertical riser, then there is ample capacity for the movement of condensation.

Report is made of a new process for cracking petroleum to secure a greater percentage of gasoline output. It is the invention of William J. Knox, of New York, and is known as the Knox Cyclic Cracking process. Briefly, the oil, widely distributed in earthenware-lined chambers, is exposed to hydrocarbon gases heated to 1200 deg. Streams of oil and gas flow continuously, as do the off-flow products, no burning resulting.

It is claimed that the process will produce 60 per cent of the crude oil as gasoline which will have an endpoint of evaporation at 350 deg., as against 33 per cent gasoline with endpoint of 420 to 500 deg. by methods now used. The lighter gasoline would give better efficiency in the cylinders of combustion engines, less carbon deposits and less dilution of the lubricating oil in the crank case.

It is also claimed that the cyclic process has low operating cost and fuel consumption, is largely automatic in control, simple and continuous, thus producing gasoline at low cost to manufacture.

It is stated that a corporation has been formed to install a plant for producing gasoline by the methods of this invention.

Some Boiler Room Problems

REVISING BLOWOFF AND STEAM PIPING; HANDLING CONDENSATE. BY H. A. JAHNKE

A RETURN tubular boiler was installed in a steam plant and located near two walls of the boiler room as shown in Fig. 1. There was nothing wrong in locating the boiler next to the two walls, but it will be noticed that the blowoff pipe is run through the rear boiler setting wall and building wall, making it necessary to locate the blowoff valve outside of the boiler room as shown at A. This made it also necessary to build a housing over the blowoff valve and piping. Whenever necessary to blow some of the dirty water out of the boiler, it was necessary to go out of doors to reach the blowoff valve and whenever the weather is very cold it is bad for the health of the fireman to say the least. Besides, after a snow-storm,

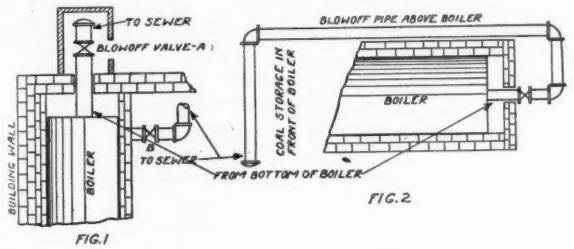


FIG. 1

FIG. 2

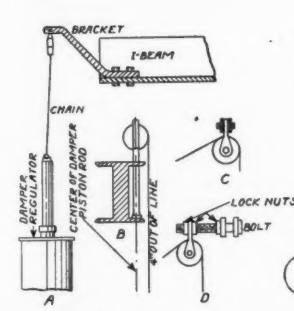


FIG. 3

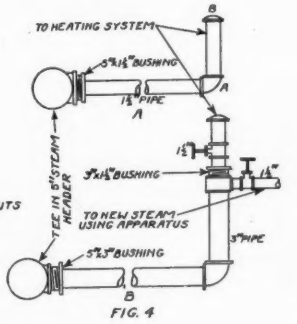


FIG. 4

FIG. 1. BOILER CROWDED INTO CORNER OF ROOM

FIG. 2. BLOWOFF PIPE ABOVE FLOOR AND RUNNING THROUGH COAL STORAGE SPACE

FIG. 3. BRACKET AND PULLEY FOR DAMPER REGULATOR CHAIN

FIG. 4. BRANCHED LEAD OBVIATES NECESSITY FOR OPENING HEADER

it is necessary first to remove the snow before it is possible to open the door leading into the housing over the blowoff apparatus. As there is not much fire under the boiler during the night, there always is the danger of the blowoff valve and pipe freezing during very cold weather.

There was nothing to interfere with running the blowoff pipe through the side wall of the boiler as shown at B, then running the pipe to the sewer. In this way the blowoff valve would be located in the boiler room where it belongs; besides, saving the expense of building the housing over the blowoff valve and piping, also the trouble of going outdoors in all kinds of weather when necessary to open the blowoff valve.

ANOTHER POOR BLOWOFF ARRANGEMENT

IN ANOTHER instance, it was necessary to run the blowoff pipe from the rear of the boiler to the front as shown in Fig. 2. In order to reach the sewer, the blowoff pipe was located above the boiler room floor along one of the side boiler walls as shown in Fig. 2, up to the building wall opposite the boiler plant and then into the sewer which was located near the building wall. That part of the blowoff pipe which was located along the building wall opposite the boiler front was always covered with coal as this space was used for coal storage and as the coal received was always in a wet condition the blowoff pipe under the coal would quickly rust through, making it necessary to renew this quite often.

Whenever it was necessary to renew this pipe it was also necessary to remove the coal that was on hand to get at the pipe, also when the blowoff pipe leaked whenever blowing some of the dirty water out of the boiler much water would run onto the boiler room floor, due to the holes in the blowoff pipe, which made a dirty mess on the boiler floor since the water had to pass through the coal pile.

This trouble was remedied by running the pipe under the boiler room floor, inclosing it in a wood box, then laying the cement floor on top of this. In this way no coal came in contact with the pipe.

PECULIAR BEHAVIOR OF WATER COLUMN

ONE MORNING while blowing out one of the water columns I noticed that I could not drain the gage glass entirely with the bottom blowoff valve wide open; then I closed the steam valve in the top column connection, as I thought that in this way I could clear the lower connection of whatever obstruction there was in it. When opening the column blowoff valve again, the obstruction seemed to be blown out of the pipe, as all seemed to be clear again. When closing the blowoff valve and opening the steam valve in the steam connection, the water rose quickly in the gage glass. When blowing out the column again, however, some time afterward, the same trouble was there.

LINING UP A DAMPER REGULATOR CHAIN

AT ONE TIME while installing a damper regulator to guide the chains from the regulator to the damper I found it necessary to make a bracket to hold a small pulley over which the chain passes and I fastened this bracket to one of the I-beams from which the boiler was suspended as shown in Fig. 3A. After having the bracket in place, I found that I had made a bad mistake. In passing the chain over the pulley and attaching it to the regulator, I found that the chain would not line up with the rod within 4 in., as shown at B. In making the bracket, I did not figure that the diameter of the pulley would throw the chain out this much. I could not offset the bracket the amount to make up the differ-

ence, nor could I use a small pulley on account of the size of the chain, nor change the location of the damper regulator, but finally I changed the position of the pulley by running a bolt through the end of the bracket where the pulley is located.

Shown at C is the end of the bracket which is slotted to receive the pulley eye which is held there by a bolt. The pulley was removed and offset from its original position by means of a bolt with a long thread, locknuts holding it in position, as shown at D.

Adding Another Steam Line

In a manufacturing plant, it was necessary to run a steam line directly from the steam header above the boilers to a steam-using apparatus which had just been installed in the factory; the apparatus needed full boiler pressure.

At first it was decided to cut into the main steam header to get an opening for the new line by connecting a tee at some point in the header. In examining the header it was found that this work would be quite an expense, besides taking much time and labor.

arate steam line from the main steam header of a number of boilers to an air compressor which had just been installed. It was decided by the management to break into the header so as to get an opening for the new line, but in examining the header, I found that one end of it was closed up with a blind flange as shown in Fig. 5A, so the blind flange was replaced by a 6 by 2-in. reducing flange that would fit the 6-in. tee on the steam header and give an opening for a 2-in. pipe connection needed for the line to the air compressor, as shown at B. This also did away with breaking into the steam header in order to get an opening, with less expense, labor and time, also no shutting down of the plant during working hours, as the work was done at night after closing time.

To break into a steam header that has been in service for a long time, as in disconnecting a number of joints to get a tee, etc., in place for the new branch, much jarring and hammering has to be done to get some of the joints apart. This usually loosens other joints also, and after the job is completed and steam turned into the header there are many leaks at some of the old joints

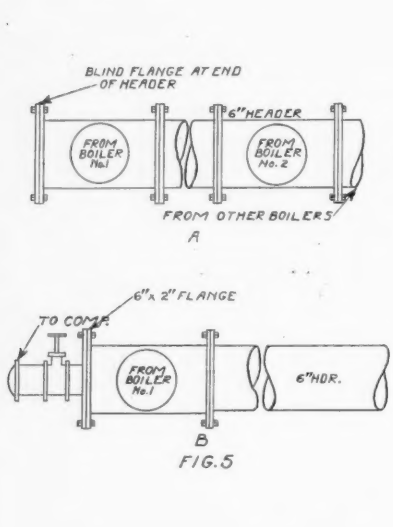


FIG. 5

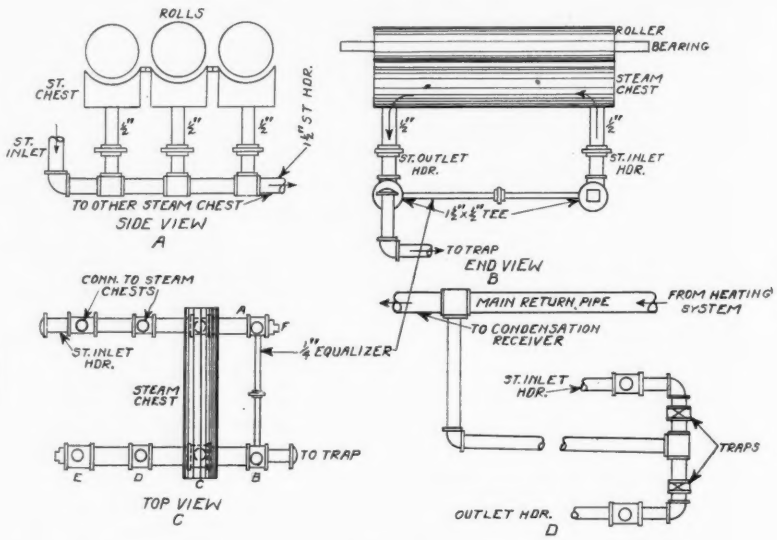


FIG. 6

FIG. 5. USING REDUCING FLANGE AS LEAD CONNECTION TO HEADER FIG. 6. STEAM CONNECTION TO IRONER

It was noticed that there was a branch in the header which furnished steam to the heating system. The steam header was 5 in. and the tee from which steam was taken for the heating system was 5 by 5 by 5 in. and the branch leading to the heating system was 1½ in.; hence there was a 5½-in. bushing in the tee, as shown in Fig. 4A. The elbow a is located just outside of the boiler room wall where it branches off to the heating system. It was decided to disconnect the heating system line at the elbow b, place a 5 by 3-in. bushing in the tee in place of the 5½-in. bushing, then run a 3-in. line up to a point outside of the boiler room wall as shown at B, and branch off a 1½-in. line to the heating system and a 1½-in. line to the new steam-using apparatus in the factory as shown. In doing the job this way, it was not necessary to break into the steam header.

In another instance, it was necessary to run a sep-

which may take up again in the course of time or may not, making it often necessary to rebuild the entire header to get the thing right again.

For this reason, if in any way it is possible to avoid breaking into a steam header to make an opening for another steam line, try first to get the opening in some other way, as stated above.

A Case of Air Binding

A large laundry installed what is called an eight-roll flat ironer, where the heat is furnished by steam chests, one located under each roll, as shown at 6A, where the steam enters one end of the steam chest, which is supplied by a 1½-in. steam header running along under the eight chests connected to them by ½-in. connections as illustrated. Steam entering the steam header at one end circulates through each steam chest while it escapes at the other end of the chest through

an outlet steam header as shown at B, from which the condensation is taken care of by a steam trap.

After the flat ironer was placed in service, it was found that it took a long time before all the air would escape out of some of the steam chests after the steam was turned on. Due to this air, the steam chests would not get air as hot as they should for a long time, causing a waste of time as well as poor work.

A number of ways to overcome the trouble were tried, such as leaving the bypass of the trap open for a long time, as I thought that in this way the air would escape in a shorter time, but I had little result. One morning while turning steam into the flat ironer and when placing my hand on the steam header at a and the ¼-in. equalizer between the twin headers as shown in the top view C, I noticed that the entire inlet steam header, ¼-in. equalizer pipe and the tee, b, were hot in a short time while the tees c, d, e and the connections between them were barely warm.

I came to the conclusion that the ¼-in. equalizer pipe between the two steam headers was the entire cause of the trouble of the air remaining in some of the steam chests and outlet header. I shut the steam off on the flat ironer again and removed the ¼-in. equalizer pipe between the two headers entirely, stopping up the holes with plugs. The steam was then turned into the flat ironer again and in a short time all the steam chests as well as the entire outlet header were hot, showing that the equalizer pipe between the two headers had caused all the trouble by trapping the air in the outlet header so it could not escape quickly. It also was found that the steam chests did not get as hot as they should even with high steam pressure, which was 118 lb., to turn out as good work as was expected. Thinking that this also was caused by more or less air remaining in the two steam headers and the chests which prevented the steam from circulating freely through the steam chests, I connected another steam trap to the end of the steam header by removing the plug f. After this, there was no further trouble.

Remedy for Slow Operating Tilting Traps

Some time after that it was noticed by some of the flat ironer operators that the steam chests would be much hotter at times, then cool off somewhat; that is, the steam chests would not have an equal temperature always.

It will be noticed in Fig. 6D that the two traps on the flat ironer discharge into one main pipe and this main pipe discharges in turn to the main return pipe of the entire heating system of the plant. This return pipe is located below the floor. Tilting traps are used in this laundry for feeding the boiler, also a tilting lifting trap for forcing the water of condensation from the heating system and flat ironer into the boiler feed traps, which in turn throw it back into the boiler. The main return pipe from the heating system runs above the floor for a distance, then a short vertical piece of pipe leads to a horizontal run under the floor. There is a union connection in this short length of vertical pipe. One day, while standing near this pipe, I noticed that this union was leaking badly and that water and steam were escaping from the leak. The entire main return pipe was filled with water.

At first I thought that the lifting trap was not operating; but when examining this, I found that it was in working order but the condensation receiver was overflowing while the trouble was that the trap did not operate often enough to take care of the condensation that was coming into the receiver. This was the cause of the uneven temperature at the flat ironer steam chests, as when the main return pipe was clear of water the traps at the flat ironer could discharge all the condensate freely and the chests would be hot, and when the return pipe was full of water the flat ironer trap could not discharge all the water freely, hence there was no circulating in the steam chests when they would cool off somewhat until the return pipe was clear again.

The exhaust or vent of the trap was connected into the low-pressure heating system and I was under the impression that this was the cause of the trouble, as the steam pressure from the heating system would not allow the pressure in the trap tank to go below that in the condensate receiver, or, in other words, it took much longer for the pressure in the trap tank, after discharging the exhaust, to get below the water pressure in the receiver while discharging into the heating system than if the exhaust was discharged against no pressure.

To prove this, I disconnected the exhaust pipe from the heating system and let the exhaust discharge into the open, when the trap operated nearly twice as fast. After this the exhaust line from the trap was run into the hot water tanks and there was no further trouble with the trap not taking care of the condensation, and also no further trouble with the uneven temperature at the flat ironer steam chests.

There was no loss in discharging the trap exhaust steam into the hot water tanks, as it made this water so much hotter.

Strength of Manila Rope

By J. B. Dillon

Much prominence has been given Technologic Paper No. 198, issued by the Bureau of Standards, subject, "Strength of Manila Rope." The formula deduced is: "For three-strand regular manila rope from ½ to 4½ in. in diameter, the following computation will give the breaking load of the rope. (The average breaking load in pounds equals 5000 multiplied by the diameter of the rope in inches, multiplied by the diameter of the rope plus one.)

The writer of this article figured out a table in accordance with the formula given, but some engineering friends told me my figures were too high, that I expected too much of a rope. I named the source of my authority, but the engineers stood firm against the results.

The figures were submitted to the Bureau of Standards, who courteously advised that they were correct and that all must understand that the formula was obtained by actual tests. Even this did not appease the opposition.

It was then I referred the case to the Whitlock Cordage Co., of New Jersey, and Louis I. Whitlock, treasurer of the company, wrote me at length. Mr. Whitlock's idea is that it is better to be safe than sorry, that in handling rope not knowing its origin we are apt to meet up with good, bad and indifferent rope and that

in his opinion it would be best to use 4000 as our multiplier, that the figure 5000 gives to rope more than it is entitled to, and that as a factor of safety he thought five would serve safely.

So the writer compiled a table covering the strength of rope, also its safe working load, using the formula diameter in inches multiplied by 4000, multiplied by the diameter of the rope increased by one, a working load of 1/5 of the product secured. The only change I have made is purposely to reduce the safe load of a ½-in. rope.

What is the life of a rope?

No blanket answer can be given. Much depends upon how it is handled. A rope should never be left exposed to acids or the elements if its natural life is

Dia. in inches	Ultimate breaking load in pounds	Safe working load in pounds
0.5	3,000	500
0.75	5,250	1,050
1.00	6,000	1,200
1.25	11,250	2,250
1.50	15,000	3,000
1.75	19,250	3,850
2.00	24,000	4,800
2.25	29,250	5,850
2.50	35,000	7,000
2.75	41,250	8,250
3.00	48,000	9,600
3.25	55,250	11,050
3.50	63,000	12,600
3.75	71,250	14,250
4.00	80,000	16,000
4.25	89,250	17,850
4.50	99,000	19,800

expected. If properly handled away from outdoor and acid effects, a rope should last for years. By "outdoor" we mean that it must not be left eternally exposed to the weather.

The writer believes that the table herewith is as near accurate—as far as practice goes—as it is possible to compile.

Free Power

GETTING free power from the wind has always interested men who marvel that, in a scientific age, so much latent power is allowed to go to waste. Although windmills were known to Europeans as early as the twelfth century, developments in this power field have come slowly. Today the common windmills of Holland, France and Germany are large, ungainly affairs with two or four sails, quite different in appearance from the American type with numerous sails, which cover a large part of the area of the field or are cut by the tips of the revolving sails.

Scientific study has convinced most windmill makers that an angle of 7 deg. at the outer end of the sail makes a good "wind-catcher." This angle sharpens to one of 18 deg. as it comes to the hub. While the width of the outer end is one-third the length of the average sail, this narrows to about one-fifth the length at the point where it joins the hub.

One unsatisfactory feature of windmills has been the difficulty in getting even power. As the wind dies, the immediate source of power is gone. To stabilize the available power has been a problem of trying to conserve the excess during periods of high wind, using this surplus when the wind offers a decreased supply of power.

There is no question of the fact that there is power in the wind. The table given below shows the power obtainable from a 14-ft. steel mill under various winds:

Miles per hour	10	12	16	20	25	30
Horsepower	0.3	0.6	1.2	2.1	3.0	3.6

One early plan for conserving wind power was to raise a large weight to the top of the tower while the wind was blowing hard. The theory was that the later falling of this weight would produce a power capable of conversion into energy. While this theory seemed sound, it was found impracticable in practice.

The custom of filling an overhead storage tank is really an application—in a less general way—of this conservation principle.

An increased knowledge of storage batteries and electricity seems to forecast an increased and more economical use of windmills. One combination, manufactured by the Perkins Corporation of Mishawaka, Ind., in use today, is storing energy by connecting a Westinghouse electric generator to a 14-in. steel wind wheel, which is left in the wind at all times. The current it generates is collected and stored in large capacity storage batteries and is ready for use at any subsequent time. In this way every bit of energy of the wind is caught, converted into electrical energy and stored in the battery.

The outfit consists of three main units, the Perkins wind wheel, generator and storage battery. The wind wheel is geared to the generator by means of machine-cut spur gears carried on roller bearings, and all running in a bath of oil. The generator is mounted at the top of the tower on the main casting, and is completely enclosed from the elements. The generator is provided with a separate system of coiling and needs attention only once a year.

The generator is of one kilowatt capacity and of 32-v. type. It is a compound machine, differentially wound, and gives a constant voltage characteristic over a speed variation ranging from 750 to 2500 r.p.m.

The storage battery used has a capacity of 280 amp.-hr. and will store enough electricity to operate the lights on an average farm for 11 successive days of no wind. This is a condition of weather very seldom found.

In addition to the three main parts, there are the collector ring which allows the wheel to turn about a vertical axle so it can face into any wind and a reverse current cutout which disconnects the battery from the generator as soon as the generator voltage falls below that of the battery. This is to prevent the battery discharging back through the generator.

A study of this system—described as typical of recent advances in conservation of wind power—leads us to believe that the modern windmill will be as far ahead of the twelfth century type (still used in certain parts of Europe) as the present automobile is ahead of the medieval cart.

IT IS PROPOSED to develop the falls of the Mamasa River, near Patewali, Celebes Id., to deliver some 200,000 hp. for manufacture of nitrates and smelting of iron and zinc.

Power Plant Records

EVERY ENGINEER desirous of operating his plant on an economical basis must employ some system whereby the operating performance of the equipment under his charge may be recorded. The actual means employed for doing this will, of course, vary according to the individual conditions existing at each plant, and in practice will be found to consist of anything from a pocket note book which the engineer carries around with him to the highly complex systems of records used by the up-to-date industrial and central station plants.

A short time ago a set of charts for recording operation in the power plant of the Bayless Manufacturing Corporation were prepared by John A. Kagerhuber and as they may be of interest to others in the profession we have reproduced them herewith. There are two reports, as will be noted, one for recording operation in the boiler plant and the other for the engine room. The charts are self-explanatory.

BAYLESS MANUFACTURING CORPORATION
Austin, Pa

BOILER HOUSE REPORT

Day or Night Tour Date.....19....

BOILER NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
In Service												
Boilers Indicating Trouble												
Boilers Down for Repairs												
Boilers Down for Other Reasons	from / to											
Fires Banked	from / to											
Soot Blown												
Blown Down												
Tubes Cleaned												
Water Columns Cleaned												
Gauge Cocks Blown												
Fires Cleaned	from / to / time											
Fires Cleaned	from / to / time											
Fires Cleaned	from / to / time											
Ave. Co2 from Collectors												
Co2 Recorder on Boiler Number	from / to											
Stoker Counter Reading												
Coal Consumed per Stoker Counter Reading												

TIME o'clock	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00
Steam Gauge Pressure													
Feed Water Pressure													
Feed Water Temperature													

Water Evaporated Lbs.
Ave. H. P. per Hour

FIG. 1 A. BOILER HOUSE REPORT

CREW	No. of Men	REFUSE BURNED	Boiler No. 1		Boiler No. 2	
Assistant Head Firemen		Fired	From		From	
Stoker Men			To		To	
Hand Firemen		Fired	From		From	
Larrymen			To		To	
Ash Handlers						
Extra Men						

COAL (Tons)	On Storage	Unloaded from Cars to Storage	Taken Into Boiler House	Balance in Storage

Carloads of Ashes Removed Tons

Why is Boiler Down for Repairs?

When Will Repairs be Completed?

What Trouble is Indicated?

Have You Reported Needed Repairs?

To Whom Did You Report Needed Repairs and When?

General Remarks on Condition in Boiler House:

(Signed) Head Fireman

FIG. 1 B. REVERSE SIDE OF REPORT SHOWN IN FIG. 1 A

ENGINEER'S DAILY REPORT
BAYLESS M'F'G CORP.

DATE.....

H.P. OF ENG.														
1	COMPOUND ENG.			DOWN		DAY		HR.	NIGHT		HR.	TOTAL RUN		HR.
	O'CLOCK	7	9	11	1	3	5	7	9	11	1	3	5	AVER. VAC.
	PRESS. AT THROTTLE													LB.
	PRESS. AT RECEIVER													"
	VACUUM													IN.
2	COMPOUND ENG.			DOWN		DAY		HR.	NIGHT		HR.	TOTAL RUN		HR.
	O'CLOCK	7	9	11	1	3	5	7	9	11	1	3	5	AVER. VAC.
	PRESS. AT THROTTLE													LB.
	PRESS. AT REC.													"
	VAC.													IN.
3	450 KW. A.C. GEN. R&S. ENGINE			DOWN		DAY		HR.	NIGHT		HR.	TOTAL RUN		HR.
	O'CLOCK	7	9	11	1	3	5	7	9	11	1	3	5	AVER. VAC.
	PRESS. AT THROTTLE													LB.
	PRESS. AT REC.													"
	VAC.													IN.

		DOWN	DAY	NIGHT	TOTAL RUN
4	No.1 MACHINE ENG.				
5	No.2 " " "				
6	No.3 " " "				
7	WOOD ROOM ENGINE	"			
8	DYNAMO ENGINE	"			
9	SKINNER 9x12 MACH RM.	"			
10	WET ROOM FAN ENG.	"			
11	MACH. ROOM TURBINE	"			
12	TROY ENG. 9x10 BOILER	"			
13	STURTEVANT ENG. BOILER HOUSE	"			
14	AMER. BLOWER ENG. 24"-1 BOILER	"			
15	AMER. BLOWER ENG. 24"-1 BOILER	"			
16	STURTEVANT TURBINE BOILER HOUSE	"			
17	SKINNER FAN ENG.	"			
18	INDEPEN. AC GEN. SKINNER ENG. CHEM. PLANT				
19					

REMARKS

D.C. UNIT
AVER. VOLTS..... AVER. AMP.....

AC UNIT 192 KW.
AVER. VOLTS..... AVER. AMP.....

A.C. 450 KW. UNIT
AVER. VOLTS..... AVER. AMP.....

OIL { ENGINE ..... PONDROS..... CYLINDER ..... GREASE..... COAL ..... GAS.....

PRESS. AT RESERVOIR	7	9	11	1	3	5	7	9	11	1	3	5	

REPORT TEST, IF ANY MADE, AND ATTACH DIAGRAMS TO THIS REPORT:-

REPORT HERE, LEAKY VALVES, STEAM CONNECTIONS OR OTHER ITEMS NEEDING REPAIRS:-

ENGINEER

FIG. 2. ENGINE ROOM REPORT

MINE SAMPLES of coal from the Chickaloon field in Alaska, submitted by the Naval Alaskan Coal Commission, have been analyzed at the Pittsburgh, Pa., experiment station of the Bureau of Mines. The analyses show high ash, low volatile coal, but it is hoped that the washing may greatly reduce the amount of ash. The Department of the Interior recently took charge for the Navy of the Chickaloon mine, the Coal Creek mine, and other prospects on Government reservations. Operations were placed in charge of the Alaskan Engineering Commission, the inspection, however, remaining under the Bureau of Mines. The Naval Alaskan Coal Commission mined during the month of April from the Chickaloon mine 2352 T. and from the Coal Creek mine 33 T. This coal was mined for the purpose of obtaining a large sample for naval testing. The Alaskan Engineering Commission is prospecting for coal with a diamond drill at Chickaloon.

Bringing Up Capacity of Ice Plant

THE WRITER had been called to an ice plant in a certain Illinois town. They were having trouble with the capacity being below normal. As it was a 20-T. ice plant, only 10 T. of ice was made.

Inspecting the plant, the following defects were noted: Low brine in ice tank, two upper pipes in each coil were out of brine; ice being pulled twice a day; that is, 3 hr. on day shift and 3 hr. on night shift; ice was pulled regardless of tank temperature, as no thermometer was on hand; insufficient ammonia and high ammonia condenser pressure, the greatest partial cause being insufficient ammonia.

They had a receiver as shown in Fig. 1, bottom of gage glass being level with bottom of receiver. The liquid outlet on opposite end, being a 2-in. nipple with reducing flanges to ¾ in. tapped in 3 in. from inside

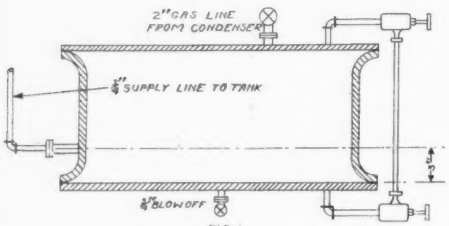


FIG. 1. AMMONIA RECEIVER SHOWING GAGE GLASS CONNECTIONS

FIG. 2. METHOD USED FOR CLEANING OUT CONDENSER PIPE

bottom of receiver. With this construction, there will be 3 in. liquid in glass before the outlet will commence to seal, as the receiver was set level. The plant engineer was of the impression that he had ample ammonia, having been previously advised that as long as ammonia liquid showed in the glass it was sufficient.

The ammonia condensers were 1½ by 2½ double pipe, water circulating through inner 1½-in. pipe. The return bends were taken off the water pipes, which were scaled badly.

They were cleaned in the following manner: a piece of 1-in. pipe was forced through the 1½-in. pipes, then the end of the 1-in. pipe was spread with a peening hammer and forced through again. This operation was repeated until the spread equaled the size of the 1½-in. pipe. Spreading the pipe a little at the time, it forced through very easily.

After raising the brine to the proper level in the tank, pulling the ice periodically and according to the temperature of the brine, charging 450 lb. of ammonia into the system, purging and cleaning condenser, the plant made full capacity and had moderate condenser pressure.

A. GASS.

Split Sheave Caused Broken Shaft

THE MAIN SHAFT, driving four large Jordan engines and a number of stock pumps in a paper mill, had been giving considerable trouble and expense to the

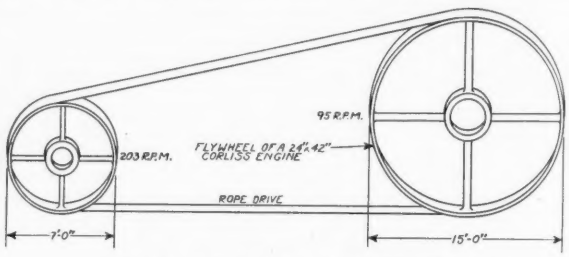


FIG. 1. ROPE DRIVE ARRANGEMENT

owners and engineers, due to breaking at least once a year.

The shaft was driven by a 500-hp. Corliss engine of the double eccentric type, having sheaves with American transmission rope drive. It was considered that the real

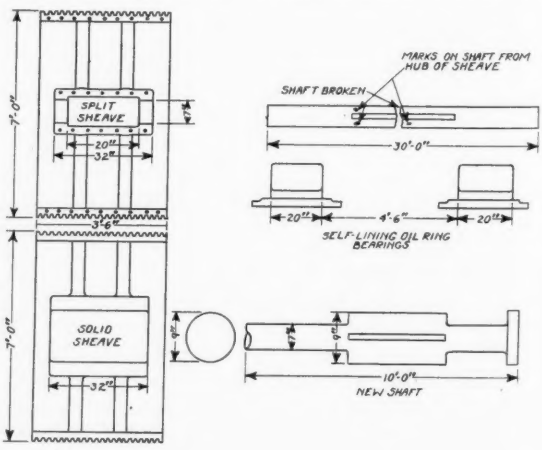


FIG. 2. FORMER AND PRESENT SHAFTING AND SHEAVES

cause of the breaking was due to the shaft not being of ample diameter to carry the load; but indicating the engine under all conditions and loads, with the speeds of the engine and driven sheaves follows: engine sheave 15 ft. dia., 95 r.p.m.; driven sheave 7 ft. dia., 203.5

r.p.m. Hp. $= D^3 \times R \div 125 = 558.4$, showed that the shaft was of ample size to carry the load transmitted.

After several shafts had broken, the management decided to hold an investigation as to what the real cause of this could be. A new shaft was installed 7 in. in diameter by 30 ft. long, new bearings of the self alining oil ring type were placed 4 ft. 6 in. apart, the sheave bolts were heated before being placed and drawn up and the sheave was tested for any opening between the hub and shaft. A continuous indicator was placed on the engine and at no time was there over 480 hp. developed. Four months from the day the shaft was placed, the sheave started to show distress by running out of line, or in a jumping motion caused from the sheave bolts starting to give. No attempt was made to tighten the bolts, as each nut had a pin through it and the bolt.

This condition existed for one week when the shaft broke, burning out the bearings, as there was no attempt made to stop the engine until we had the full data as to what the cause might be.

After removing the sheave, which had to be done by cutting off the bolts, it was found that the shaft had broken in a straight line through the center between the bearings and as shown in the sketch, bright marks were visible on either side of the shaft where the sheave had hammered at each revolution, which, it was decided, was the real cause of these shafts breaking.

A new sheave of the solid type and shaft 7 in. in diameter at the bearings and 9 in. in the hub of the sheave by 10 ft. long with coupling to connect on the section of shaft which drove the machinery was placed.

The new shaft and sheave have been in constant operation for two years and are not showing any depreciation nor have they caused any trouble up to the present time.

CHAS. J. MILLER.

Reducing Fuel Consumption and Eliminating Smoke

LOCAL CONDITIONS existing in a Mid-western steel manufacturing plant of medium size rendered it advisable to discontinue the generation of electric power and as a consequence two of three 72-in. by 18-ft. return tubular boilers of the horizontal type were sold. Each of the units had been equipped with under-feed stokers; but because of the fact that a fireman had to be retained and on account of the comparatively large amount of high-pressure steam needed to operate both the stoker proper and the blowers, the stoker on the remaining boiler was also removed.

In changing over from stoker to hand firing, the only alterations made were the breaking of the sealed ash pit doors and the installation of plain grate bars, giving a grate area of about 36 sq. ft., the over-all dimensions being approximately 6 by 6 ft. The general arrangement of the setting was as illustrated in Fig. 1, a scheme which, however, proved exceedingly unsatisfactory both from the standpoint of economy and smoke nuisance. In fact, the latter became so objectionable as to cause neighbors to make complaint to the local authorities with the result that immediate action became necessary. Various smoke consuming and eliminating appliances and devices on the market were studied and investigated, but each appearing favorable and applicable to the situation proved exceedingly expensive to install.

A study of conditions indicated that complete combustion was not taking place and as the first step toward correcting this state of affairs, the bridge wall, which had been a minimum distance of 18 in. from the lowest point of the boiler shell, was raised to within 10½ in. and instead of being continued as shown in Fig. 1, was made so as to deflect the flame and unburned gases slightly forward, thus causing these, as illustrated in Fig. 2, to be brought more intimately in contact with more shell surface than would have been the case otherwise. These changes in the setting helped matters considerably but still left room for improvement.

The next step taken was the construction of a double opening arch which was placed midway between the rear of the bridgewall and the rear setting wall with the combined area of the two arch openings about 25 per cent greater than that above the bridgewall, thus

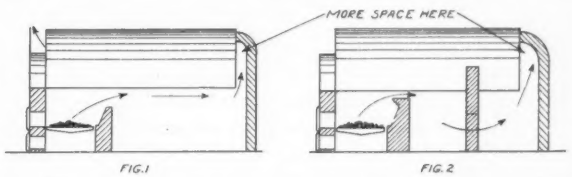


FIG. 1. SHOWING ORIGINAL SETTING; SMOKY AND WASTEFUL OF FUEL

FIG. 2. WITH THIS ARRANGEMENT BETTER COMBUSTION OCCURRED; THE IMPROVED ARCH BRINGS THE HOT GASES INTO MORE INTIMATE CONTACT WITH THE BOILER SHELL AND THE ARCH WHEN HEATED PROVIDES A MEANS FOR IGNITING THE OTHERWISE UNBURNED GASES

allowing amply for the expansion of the hot gases as they passed through the setting. With the completion of this change, it was found with proper firing that the smoke nuisance had been reduced to a minimum and a considerable saving of fuel realized.

O. H. HENSCHEL.

Leaking Flanges

SEVERAL letters have appeared lately in the technical press in reference to flanges leaking, especially on high pressure steam lines. There are a number of possible reasons for this trouble. By using care when installing, having a knowledge of the existing conditions where the flanges are to be located and using the proper material, there will be no trouble from leaking flanges.

Mr. Schaphorst, on page 777 Aug. 1 issue, suggests that the builders of pumps and engines commonly equip their machines with flanges under strength, that the bolt holes are too few in number and too small in diameter. Some years ago there may have been reason for such a charge, but for many years practically all reputable manufacturers of such machines use full weight and often greatly overweight on all such flanges, especially if made of cast iron, as they usually are. This will not prevent the incompetent worker from using improper bolts.

Leaking flanges are often due to the fact that ⅛ or 3/16-in. sheet rubber is used when it should be 1/32 or 1/16-in. The material may be of the best, but too thick for the work. Have the flange faces in line,

clean and in good condition; have the gasket clean, thin, and of good material. If you use graphite or other lubricant on the flange or gasket, see that it is clean, free from grit or lumps of any kind. Conditions being so, connect up the flange and there is small chance of leaks occurring or following up required after the first hot tightening. How can a flange be expected to remain steam tight if a thick sheet rubber gasket is used and the flange located in a location where it receives the full effect of a cold draft intermittently besides being subjected to the regular strains of expansion and contraction?

Some years ago while employed as steamfitter and power plant trouble man I was called upon to repair a sectional steam press which gave difficulty in securing a permanent steam tight job. I separated the press and cut a gasket 18 by 30 in. from 1/16-in. sheet asbestos paper. Placing one half of the press flat, I laid the gasket upon it. I poured water upon it, then with the aid of a chain block I carefully lowered the other half of the press upon the wet gasket. Great care had to be used, as this wet sheet of asbestos paper is as easy to tear as tissue paper. The press was bolted together and steam turned on just enough to heat the press and dry out the gasket, then the full pressure was turned on. Such a job is practically face to face, no following up is possible or required. When I left the employ of the firm 3 yr. later, the press was still steam tight after being in constant use, steam being turned on and off, thus heating and cooling the press, from 20 to 40 times daily. JAMES E. NOBLE.

Diagram Taken After Long Service

IN THE Diamond Mills Paper Co.'s plant at Saugerties, N. Y., a Lentz engine, 23 by 30 in., was installed 8 yr. ago and since that time has seen day and night service without a single adjustment of the steam valves.

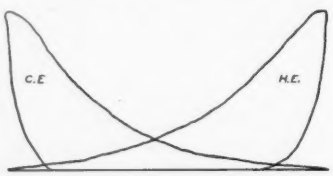


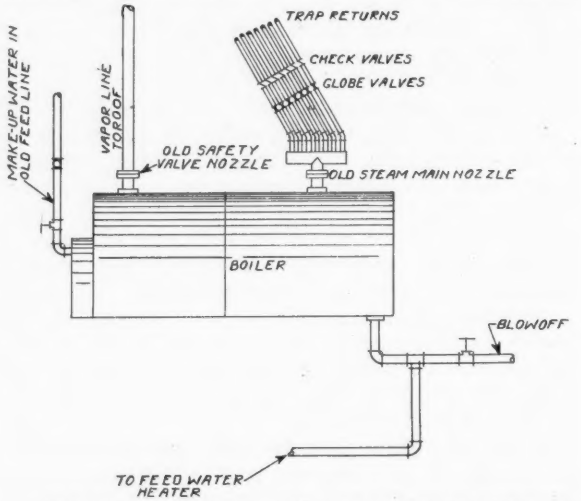
DIAGRAM FROM LENTZ ENGINE AFTER 8 YR. WITHOUT ADJUSTMENT

Recently an indicator diagram was taken and is reproduced herewith as an example of what may be accomplished with an engine of the poppet valve type when proper operating care is given it.

Using Old Boiler for Storage Tank

IN A TEXTILE mill, steam is used only for drying, dyeing, pressing, etc., besides heating the mill in cold weather. Because of enlarging the capacity of the mill 8 yr. ago, the original 60-in. by 16-ft. boiler was abandoned, and a 72-in. by 18-ft. boiler was installed, carrying an increased steam pressure. The old return-tank, a 15 by 26-in. cast-iron affair, was retained in use, but it was far too small. When a large amount of steam was being used in the different processes, the returns from the traps came back faster than they could be used in the boiler, consequently a great deal of water was wasted at the overflow. At other times there would be no hot water available to feed the boiler, and cold water would have to be used for that purpose, which, besides being a waste of coal, was very detrimental to the boiler plates.

Recently it was suggested to use the old boiler as a storage tank for the hot water returns. Accordingly, the connections of the old steam, and safety valve, were opened on the old boiler, and the piping arranged, as shown in the sketch. A manifold to receive the returns from the eight traps was bolted to the steam nozzle. A vapor line connected to the safety valve nozzle was run to the roof. Make-up water from the penstock was connected to the old feed pipe. The suction of the boiler feed pump was connected to a tee, inserted in the blowoff pipe. There was also a 1-in. line taken off the



OLD BOILER CONNECTED UP AS A STORAGE TANK

blowoff pipe (not shown) for washing down purposes. There is now an abundance of hot water in reserve at all times. It is estimated that it requires from 600 to 800 lb. less coal per day, since the cold water feed has been cut out. It is rather appalling to figure the loss in coal in the past 8 yr., and a great wonder that there has not been considerable expense for boiler repairs. This mill operates five days a week, so that the water in storage has time to cool considerably, in the other two days. As the old boiler setting is intact, it is proposed to burn in it, on Sundays, the rubbish, which accumulates through the week, to assure warm water at the start on Monday mornings. There is a grease extractor on the exhaust of the feed pump, and it is thought that in cold weather the exhaust from the pump may be turned into the old boiler, if it seems necessary to add more heat to the feed water. M. M. BROWN.

Running a Balky Feed Pump

THE PUMP had a lift from a tank approximately 5½ ft. and had never run satisfactorily. It would race and bang away until it caught water enough to quiet it, and then lose the water again, and repeat the process of trying to smash its way outdoors in an endeavor to regain its water once more.

The cause of losing its water so frequently was due to the changing temperature of the returns emptying

into the tank and which at times became so hot the pump became "vapor" or steam bound.

It became so bad at times that a ¼-in. line was tapped into the horizontal length of suction pipe to pump supplying cold water under city pressure.

This was used in starting the pump, but should have been used continuously, as will be seen later.

When the pump became "steam" or "vapor" bound, it appeared as if the valve motion was uneven at these times of starting, unless one were familiar with the pump.

This accounted for a piece of leather ¼ in. thick which had been hung on the valve rod to reverse the stroke.

The valve motion had also been adjusted so the tappet end that carried the link reversed the pump earlier in the stroke at this end.

Make-up water was furnished from city pressure and it had been the custom to keep the tank nearly full by this means.

In starting the pump for the first time, it acted as if the water end either needed packing, or else the valves were broken, or springs not working properly. Investigation proved them to be all right.

I next evened up the valve motion, removing the leather, which appeared unnecessary. These few changes did not seem to improve the running condition of the pump.

Next I tried feeding all the water for make-up through the suction pipe of the pump by the ¼-in. line previously spoken of and here seemed to be the secret of keeping the pump running continuously and normal, and not losing its suction.

So much for this, but there still remained the difficulty of getting the pump to run slow enough to maintain a steady water level in boiler.

After the speed had been reduced to a certain point (which was too high for normal conditions), it would stop.

As there was no foot valve on suction pipe, this allowed the water to drain out of pump suction and when it did start it was the same story of trying to catch water together with all the unpleasantness and noise.

The lubricator was too small and needed refilling twice daily, also the cup on the steam chest. These had been neglected, no doubt. The sight feed glass had a habit of plugging up every so often which did not help matters any.

The packing on rods did not appear to be giving any undue friction, so I decided to try to get more oil to the pump. This worked out all right too, because gradually the pump could be slowed down until it would not pump fast enough to maintain the water level in the boiler.

A foot valve would seem to be the thing now to complete the smooth running of pump. LEROY BLAKE.

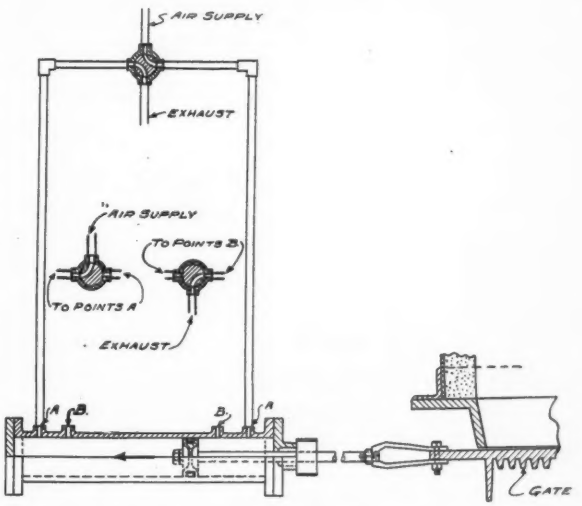
Ash Hopper Design

THE sketch shows the simple mechanism connected with an ash hopper dump as actually used in large power plants in the eastern part of the United States. The drawing has been made so distinct and complete that there is possibly nothing to say about the design in words.

The sketch shows a section through a part of the ash hopper itself. Just below the ash hopper is the gate which is held in position by means of guide angles. This gate is pulled open and then closed by means of compressed air, the air cylinder being shown in section at the left.

Air is admitted into one end of the cylinder by simply manipulating the four-way cock as shown on the top at the left. This cock is so designed, as shown, that when in one position the air admission and air exhaust are in correct position for shoving the gate in one direction. Then by swinging the four-way cock through 90 deg. the position of the four-way cock is turned for pulling the gate in the opposite direction.

The sketch also shows the cross section through the valves themselves and also through the air cylinder showing the piston in the cylinder, the piston rod passing through the stuffing-box, and the connection with the gate.



COMPRESSED AIR CYLINDER AND PISTON FOR OPERATING ASH GATE

This system is being operated with entire satisfaction and has already been copied by a number of large power plants which certainly speaks well for the method.

R. von Fabrice of the Public Service Construction Co., of Newark, N. J., is the originator of the design.

W. F. SCHAPHORST.

Temporary Pipe Repair

IN THE Aug. 1 issue of Power Plant Engineering I saw an article contributed by H. A. Jahnke stating the method he used for stopping a leak in a hot water pipe. My way of repairing pipes where holes have rusted through is to whittle a wooden plug cone-shaped, leaving the large end somewhat larger than the hole and drive the plug in until tight. This requires only a minute and can be done without shutting off the supply of water or steam as the case may be, and will hold against ordinary pressure. R. CUPPS.

ANY OLD LANE is a long lane when you're running with a flat tire.

A Page of Kinks From My Field Book

In certain industries, extension lights are hung over machines to be used by cleaners, repairmen, etc. Having been used, they should be returned to their proper place, but this is very seldom done, resulting in the cords being walked on, or getting caught in a machine and destroyed. Figure 1 illustrates a device that eliminates the personal element in the return of the light to its proper place. The roll is set above the machine and is a common window curtain roll, with the same type of ends as is used in house blinds.

In laying out plates for boilers or other work of that kind, it is sometimes necessary to have marks for cutting or riveting on both sides of the plate. The plate marker illustrated in Fig. 2 will prove useful in this work. The range of the marker will, of course, depend upon the length of the arms.

A simple method of locking a nut on wood work is to cut out of heavy tin the design shown in Fig. 3, turn the two ends, b, down and slip over bolt and drive into wood set up nut, and turn up sides, a, and the bolt is there to stay.

To find the diameter of a wire without a gage, take a common lead pencil and mark the distance one inch on it. Wind the wire around the pencil over this

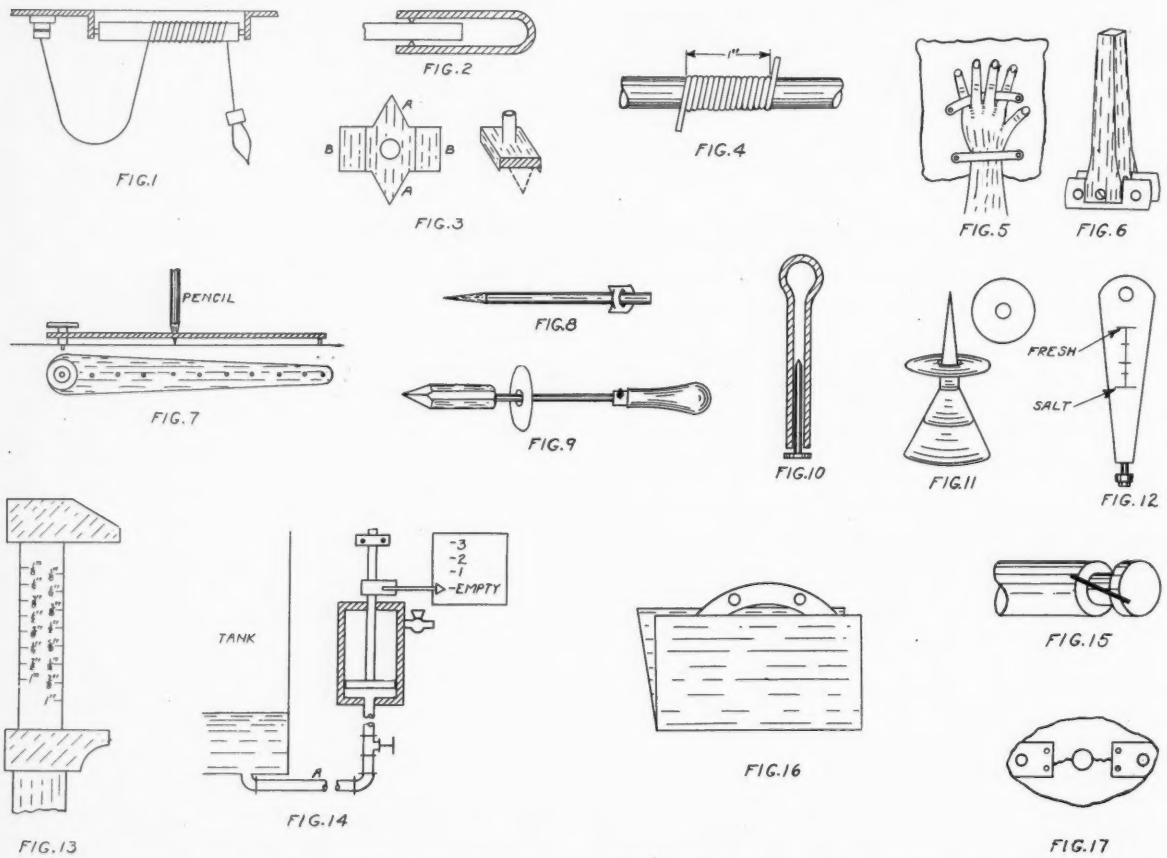


FIG. 1. SELF-WINDING EXTENSION LIGHT. FIG. 2. PLATE MARKER. FIG. 3. WASHER AND LOCK NUT. FIG. 4. METHOD OF FINDING WIRE DIAMETERS WITHOUT A GAGE. FIG. 5. GLOVES FOR FIREMAN. FIG. 6. BELT LACING CUTTER. FIG. 7. DRAWING A LARGE CIRCLE. FIG. 8. TO PREVENT PENCIL ROLLING FROM DESK. FIG. 9. GUARD ON SOLDERING IRON. FIG. 10. HANDY EXPANSION BOLT. FIG. 11. NON-SPILLABLE OIL CAN. FIG. 12. GAGE FOR FINDING DENSITY OF SALT WATER. FIG. 13. SCALE ON WRENCH. FIG. 14. WATER LEVEL INDICATOR. FIG. 15. MANDREL FOR CUTTING PACKING. FIG. 16. METHOD OF INSERTING GASKETS. FIG. 17. REPAIRING CRACKED PUMP GLAND.

distance, and divide the length of the wound part by the number of coils and obtain the diameter of the wire in fractions of an inch.

Gloves for firemen may be made by taking a piece of leather, old boot tops are good, and riveting straps as shown in Fig. 5. A better, more durable, and cooler glove is provided for the handle of slice bars, pokers, etc., than can be bought.

To make a belt lacing cutter, take a small block of wood and shape for the hand. In one end cut slots into which set two used safety blades as in Fig. 6. Very good work can be done with this device.

For drawing a large circle cut out of thin, hard wood a piece shaped as in Fig. 7, the length being such as to cover all circles you may have to make. Drill in head end a hole for center pin and throughout bar holes for a lead pencil. On under side set in small wheel to take weight off bar. With very large circles one man should hold the center pin in place while another marks the circle.

One of the things that is annoying is to have your pencil roll off your desk or table and to be unable to find it. To eliminate this a small leather clip like that shown in Fig. 8 can be made in a few moments, and no pencil will roll with this device on it.

In working in private residences, in fact, in many places, great care must be taken not to allow your soldering iron to come in touch with the floor. By putting a 6-in. washer around the solder bar, it can always be left in a position that will do no harm.

A handy expansion bolt may be made by using common cotter pin of the size of the hole you wish filled. Put the pin in a vise and roughen up the outer side of pin. Drop a nail in the hole and drive in cotter pin, as shown in Fig. 10, and for small work this will be found to exceed for tightness the common expansion bolt.

To make a non-spillable oil can, cut a ring of tin, Fig. 11, slip over spout and solder. In the event of the can tipping over, it will not spill oil.

It is sometimes necessary to know the density of salt water. Cut the gage according to Fig. 12. On the bottom put a small nut to keep the gage in a vertical position when in water. On the upper end make a small hole for string or wire fastening. Set the gage in fresh water and mark the line, then set in water that has the proper density for your work and mark the line.

A handy arrangement is a scale on the side of a monkey wrench; this allows the wrench to be set for the particular nut that is to be adjusted. I have seen men spend 15 min. trying to get a wrench to take a nut that was in a hard place to get to; this arrangement eliminates that. Scale should be marked after jaws are set on standard nuts of the given sizes. The sizes given are in fractional parts of an inch. Two scales are given, one for square nuts and one for hexagon nuts.

When a tank is located some distance from the point where the indicator is needed, run pipe A, Fig. 14, from lowest part of tank to point where indicator is located. The indicator is a small cylinder with a water-tight piston. To the piston rod, an indicating arrow is attached which indicates on a scale board the exact height of the water in the tank. In setting up this arrangement, care should be taken to have the two readings exactly alike. This can be done by measuring the water in the tank and locating the scale board to correspond. The piston should work very freely. The pet cock is a test cock for a leaky piston.

For cutting packing, make a wooden mandrel as illustrated in Fig. 15. Have the groove the same size as packing. Cut diagonally across the groove a slot that will take a packing knife. In using, fill groove with packing and cut in knife groove. This method is a clean way to cut packing and eliminates waste. Mandrels can be made for all sizes of packing at small cost.

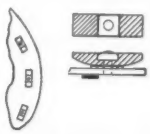
To insert gaskets between pipe flanges take a piece of manila paper and fold over to fit the gasket, leaving one bolt hole in the gasket clear, slip the gasket and its paper cover between joints, put in one bolt, take up if possible on joint until the paper is slightly pinched and then draw out the paper.

A gland cracked while a pump was in service. As there was no new gland in stock the old gland was taken to a shop and two straps were made to fit the sides and clear the rod. Holes were drilled for gland bolts and for set screws. The work was completed in one hour and a half and Fig. 17 gives an idea of its appearance.

ARTHUR D. PALMER.

Substitute for Thumb Nuts

SOME THUMB nuts were recently needed for a manhole cover on an oil tank. Away from a general hardware store, you can sometimes get them in the size you



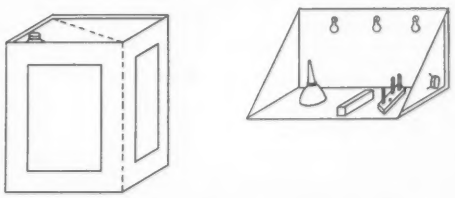
SKETCH SHOWING METHOD OF MAKING IMPROVISED THUMB NUTS

want, and sometimes you cannot. We could not. A fairly good substitute for them was made from a stick of hardwood, and some tools from the carpenter shop. Until it was possible to get the real thing, these makeshifts did nicely.

FRANK W. BENTLEY, JR.

Unique Small Ware Shelf

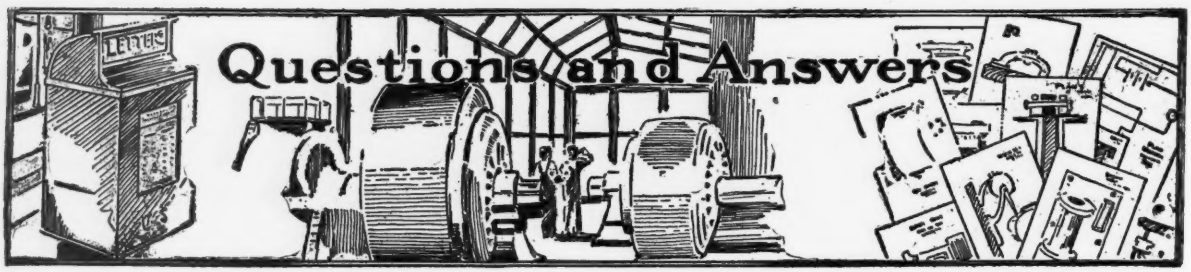
THE SKETCH illustrates how one may easily provide himself with a light weight yet substantial shelf for the workshop wall.



SHELF MADE FROM 5-GAL. OIL CAN

The only thing required to make it is an empty 5-gal. oil tin. This is carefully cut in half diagonally, as indicated in the dotted lines of the sketch, and three holes are made to hang it, as shown.

CHAS. H. WILLEY.



Receiver Relief Valve

WILL SOME one of the readers of Power Plant Engineering kindly supply me with a simple formula for determining the proper size of relief valve to be used on the receiver of a cross compound engine? What for instance would be the proper size of a valve to be used on a 30 by 60 by 65-in. Corliss cross compound, steam pressure 140-lb. gage, receiver pressure 10-lb. gage, and 28-in. vacuum? This receiver is at present fitted with a 3-in. valve. F. W. R.

Boiler Efficiency Test

WILL YOU kindly figure out the combined boiler and furnace efficiency from the following data taken from one of our daily operating logs?

1. Coal burned, lb	108,275
2. Water evaporated, lb	1,009,000
3. Heating value of coal, B.t.u. per lb	14,700
4. Steam pressure, lb. gage	120
5. Feed water temperature, deg. F	184
6. Superheat, deg. F	40

L. A. J.

A. Actual evaporation is the total water evaporated divided by the total coal consumed, (item 2 ÷ item 1) = 1,009,000 ÷ 108,275 = 9.32 lb.

The amount of heat absorbed per pound of water evaporated is equal to

$$H = (H_1 - q_2 + c \times t)$$

Where H_1 is the total heat of steam at 120 lb. gage, which, we find by referring to steam tables, is 1191.6 B.t.u., q_2 is the heat of the feed water above 32 deg. F. = 184 — 32 =152 B.t.u., c is the mean specific heat of superheated steam up to 40 deg. F. at 120 lb. pressure, and is equal to 0.565, t is the degree of superheat = 40 deg. F.

Substituting these values in our equation we have

$$H = 1191.6 - 154 + 0.565 \times 40 = 1062.2$$

The overall boiler and furnace efficiency is equal to the amount of heat actually absorbed by the water divided by the amount of heat supplied. As there are 9.32 lb. of water evaporated per pound of fuel burned, the total heat absorbed per lb. of coal is $1062.2 \times 9.32 =$ 9899.7 B.t.u., and the efficiency is $100 \times 9899.7 \div$ 14,700 = 67.4 per cent.

Centrifugal Tension in Belting

REFERRING TO the article by W. F. Schaphorst in Power Plant Engineering for March 15, I would like to say that for some time past I have been making a study of belting and find Mr. Schaphorst's article, "What is the Matter with Belt Theory" interesting, but I can not agree with his conclusion. A question that I have always found interesting in belt design, and one which he seems to ignore, is that of the tension in the belt due to centrifugal force.

It will be noticed that the belt mentioned in his article has a speed of 5300 ft. per min. The formula for centrifugal force found in the standard hand books is:

$$F = WV^2 \div g$$

where F is the pull on the belt in pounds, W is the weight per foot of belt, V is the velocity of the belt in ft. per sec., and g, the acceleration due to gravity

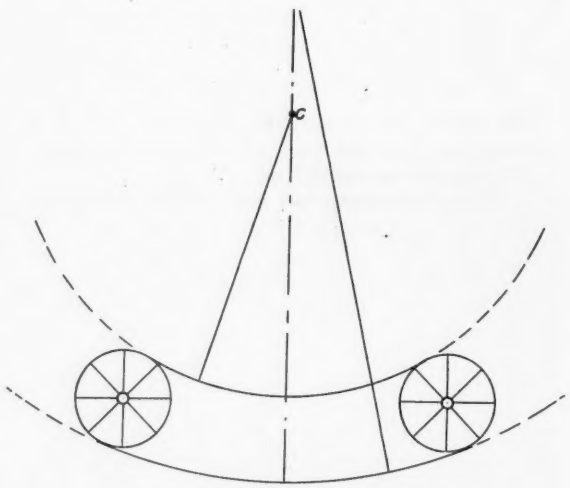


FIG. 1. TYPICAL SLACK BELT DRIVE

is 32.16. The weight of a 12-in. leather belt ⅜ in. thick would be about 1.75 lb. per ft. Substituting in this formula, we have:

$$F = 1.75\ (5300 \div 60)^2 \div 32.16 = 424 \text{ lb.}$$

Mr. Schaphorst has estimated that the total tension on the slack side, due to the sag of the belt, is only 27 lb.

What has become of the centrifugal tension amounting to about 400 lb.? W. B. C.

A. I will not go into the mathematics of the case because I believe that by means of the sketches and the photographs herewith and the formula which W. B. C. gives, namely, $F = WV^2 \div g$, it can very nicely be shown that centrifugal force has practically no effect on the position of an ordinary belt on a horizontal drive.

Figure 1 shows a typical slack belt drive on which I have endeavored to indicate by means of a large dotted circle that the slack side of the belt moves around an invisible center which I have marked "C." It is true that when a belt is slack its form is not a perfect arc of a circle, nevertheless it is at all times moving about a so-called "instantaneous center" and as long as any

object moves about a center it is subject to the laws of centrifugal force.

In the same way the lower side of the belt, usually called the tight side, is not a perfectly straight line but it has its own sag also due to the weight of the belt. Therefore it also moves about an invisible center which is much higher of course than center "C" but while moving from pulley to pulley every particle of the belt on the tight side is also subject to the centrifugal force laws.

Therefore, since the formula as quoted by W. B. C. is $F = WV^2 \div g$ it is plain that there is no variation whatever in centrifugal tension around the entire belt. In other words, the centrifugal tension is just as great in the belt halfway between the pulleys as it is at any point in contact with the small or large pulley.

About the only effect that centrifugal tension has on the horizontal belt is to cause the belt to stretch and thereby it increases the sag and increases the arc of contact on the two pulleys which is a good thing according to my way of looking at it. Where the smaller

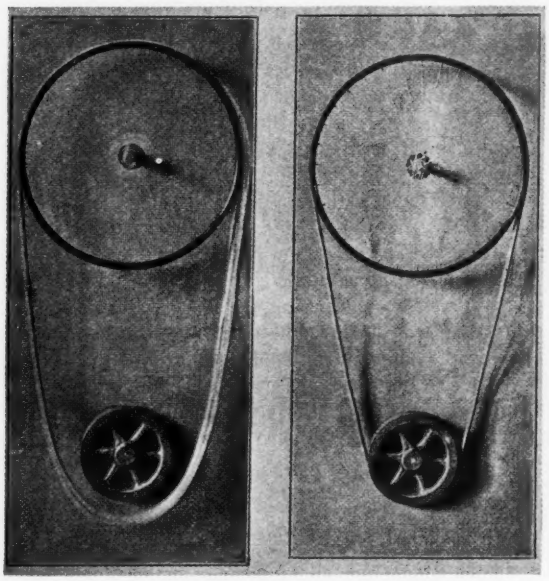


FIG. 2. ACTION OF INDIA RUBBER BELT AT HIGH SPEED

pulley is very small and where the distance between pulleys is short, it is true that centrifugal force has a tendency to lift the belt off the small pulley but that is due only to the small radius of the small pulley and is due to the force usually known as centrifugal force which acts at right angles to the force which we are discussing here, namely, centrifugal tension. Centrifugal force varies in different parts of the belt but centrifugal tension does not. The equation for centrifugal force is $WV^2 \div Rg$, where R is the radius. The radius varies.

Professor Goodman has shown this nicely in his book, "Mechanics Applied to Engineering," by means of two photographs, shown in Fig. 2, of an India rubber belt running at high speed, and at rest.

I wish to point out in this connection even in this vertical belt that practically the only effect centrifugal tension has is to stretch the belt. If one would hang a chain or flexible cord over the upper pulley of the same length as the stretched belt it would occupy almost identically the same position as this high speed belt.

It is likely true, that in the leather belt mentioned in my article there is a centrifugal tension of 424 lb. This centrifugal tension certainly exists but it does little harm in long center drives at ordinary speeds. At exceedingly high speeds, to be sure, the belt will be weakened due to the centrifugal tension but the tractive power or "ability to pull, due to greater friction" will probably be increased, due to the increased arc of contact. I assume here that the belt is properly treated with a good belt dressing.

In this connection I wish to point out the value of properly dressing a belt in such a way that it can be run slack. By running "easy," without initial drum-string-tension, the pressure or pull on the bearings is greatly reduced.

The formula used for solving any tension for any sag; any material (steel cables, electric cable or wires, ropes, suspension bridges, belts, etc.); and with any distance between points of attachment, is:

$$T = PL^2 \div 8D + PD \text{ (lb. per sq. in.)}$$

where P is the weight of the material under consideration, one ft. long and one sq. in. in section. (For leather, such as used in belts P = 0.43, the value used in obtaining the figures below); L is the length of span in feet; and D is the sag, also measured in feet.

Taking a drive that has common, every-day dimensions—30 ft. between shaft centers; a 3 ft. pulley driving a 6 ft. pulley; a belt which is one square inch in section (equivalent to a single ply leather belt 4½ in. wide); we get the following tensions by varying the sag of the slack side from ½ in. to 4 ft. The enormous change in belt tension is interesting and instructive.

Sag, in.	Tension, lb. per sq. in.
½	1160
1	580
2	290
3	193
4	145
6	97
12	49
24	25
36	17.4
48	13.8

As a study of the figures will indicate the tension varies inversely as the sag in an almost exact proportion.

W. F. SCHAPHORST.

Would the Installation of a Condenser Be Advisable?

REFERRING to the question on the installation of a condenser in the flume of a water wheel, by R. H. S., on page 727 of the July 15 issue, I would say that without more complete data only a general answer can be given. No data is given as to the size of the engine, length of cutoff or steam pressure carried, what the steam consumption is, or the amount of exhaust steam used for process work, or the amount of auxiliary apparatus used.

The idea is all right from its general appearance, but the size of the flume must be such that with the resistance offered by the coil of pipes plus all refuse which will

collect therein, it will not interfere with the proper amount of water being supplied to the water wheel, or the power lost on the wheel will offset the saving on the engine.

The larger the engine the larger would the coils need to be. The amount of saving would probably be from 20 to 25 per cent, that is, with from about 20 to 25 or 28 in. of vacuum, provided the length of the cutoff, on the engine, was long enough to stand the reduction which would automatically occur with decreased back pressure. If there were other steam operated auxiliaries to be run condensing on this coil, there would be a saving on them also, which would greatly reduce the fuel consumption of the plant for the summer season.

Then there is the question of the size of pump to handle the condensate from the condenser and a suitable storage tank for storing the condensate. The amount of oil contained in this condensate must be extracted to a point where it would not be injurious to the boilers, and the first cost of such equipment may be of great importance in such a case.

The coil of pipe would have to be made in a manifold form with a suitable large inlet to allow the steam to be distributed evenly and quickly in order to be readily condensed.

The individual installation must be studied by itself to find the probable amount of saving that could be made. The problem simmers down to the questions of:

1. The size of the engine, length of cutoff.
2. Amount of steam operated auxiliary apparatus to be operated condensing.
3. The size of penstock or flume to supply both coil and water wheel.
4. Cost of condenser construction and installation with condensate pump.

The coil would need to be of brass or copper, to prevent rusting out, as it is constantly submerged in water, whether in service or not. A system of screens would be necessary at the end of the flume, of much finer mesh than that used to keep rubbish out of the water wheel, and this would further reduce the velocity of water through the flume. I doubt if the flume is large enough to supply the water wheel and the coil. Why not install a jet condenser? It would be much cheaper, if the water is at all clear. If the water is dirty, a surface condenser would probably be the more economical.

R. A. CULTRA.

Syphon Condenser Operation

F. W. R., IN the issue of July 15, brings up an interesting question regarding condensers and vacuum. Atmospheric pressure at sea level is equal to 14.7 lb. per sq. in., and will support a column of water 33.8 ft. high.

Now, as the condenser is 34 ft. above the top of the hot well, it would be absolutely impossible to flood the engine with the foot valve open because with a perfect vacuum, atmospheric pressure could only maintain a column of water 33.8 ft. high. The above is true regardless of any holes at any place in the tail pipe.

Steam alone will not create a vacuum, therefore some external means will have to furnish water to the condenser until a vacuum has been created after which it will furnish its own condensing water.

The vacuum breaker is merely an automatic device that opens when a pressure appears in the exhaust pipe and permits air to flow into it thus breaking or destroying the vacuum that may be in the condenser, thus preventing the flooding of the engine in case the condenser was lower down. Blowing steam into the condenser without water to condense it would destroy any vacuum that might be there. With the engine down and sufficient vacuum in the condenser, I would say that it would pick up the condensing water and the syphoning action would keep it going until the vacuum was broken by leakage and air coming in with the water. L. J.

Indicator Diagram Criticism

REGARDING the diagram submitted by B. L. S. in Aug. 1 issue, I believe if a stronger spring were used he would get a better looking diagram. A light spring and a high speed tend more or less to produce wavy lines. He should also see that the indicator piston is well oiled and the indicator itself is hot, as condensation is also a cause of waves. Sometimes the indicator card will vibrate, causing irregular action of the indicator. I think I would try the indicator first for trouble.

The diagrams of D. M. B., same issue, show that the head end has a very late steam admission. The compression is plenty high, but when the steam valve opens the pressure drops and then starts to rise slowly, reaching the full pressure after the piston has moved a little over 3 in. on its stroke. There is a little hook in the compression line of the crank end diagram which may either be condensation or a leak. Probably an earlier steam admission on that end would help.

J. J. E.'s diagrams show no compression. I wonder whether this engine is very noisy at this speed and steam pressure, with no compression. If this engine has two eccentrics, I would move the exhaust eccentric ahead in direction of rotation and also lengthen the exhaust radial rods a little. In case there is but one eccentric I would also lengthen the steam rods in order to cut down the lead, and take care the dashpot rods are not long enough to cause trouble. The head end steam valve is a little late in opening, causing the steam line to slant in.

The atmospheric line is not shown on the card; the exhaust line is peculiar enough to warrant the belief that it is only a trick card. TOM JONES.

REFERRING to the inquiry of D. M. B., concerning an indicator card from an ammonia compressor engine, I would say that the crank end exhaust valve leaks, as evidenced by the projection at the end of the compression curve. The lead at the crank end is a little late, as shown by the sloping steam admission line.

The head end diagram shows an entire absence of lead; the steam valve at this end opens too late for correct operation of the engine, as indicated by the sloping steam admission line on this end.

Both head end and crank end exhaust valves open and close too soon for good economy in operation. For such a slow speed engine there is no necessity for such high compression pressures as indicated by the diagrams. Power is wasted in the high compression, and also in the early opening of the exhaust valves. Therefore I would suggest that the steam and exhaust valves at both ends be readjusted for an earlier lead, and for a later opening and closing of the exhaust valves. This may

mean a complete resetting of the entire valve gear and eccentric.

Undoubtedly the suggested changes will effect economy in steam consumption and I believe the mechanical features of operation will be improved also. If D. M. B. cares to carry out the suggestions offered, it would be informative to other readers to learn from him just what results will have been gained, when time "tells the tale."

Both cards (head end and crank end) submitted by I. J. E. indicate an entire lack of compression.

Here is a case where the speed, 130 r.p.m., might be considered high for this type of engine. A certain amount of compression is required to cushion the moving parts under the existing speed condition, yet there is none in evidence. The exhaust valves close too late. The other steam events are good for both ends. All that is necessary is to readjust the exhaust valves to give a little earlier closing, and thus produce a rounding corner on each diagram. Not much compression is required but it is not correct from any viewpoint to have none at all as at present. CHARLES J. MASON.

Condensing Water Required

WITH AN inlet temperature of 70 deg. F., how much water will be required to maintain a vacuum of 28 in. of mercury in a barometric condenser? Our steam consumption amounts to about 16,000 lb. per hr. F. C.D.

A. The amount of cooling water required per pound of steam condensed in a barometric condenser may be determined from the equation

$$R = H - t_2 + 32 \div (t_2 - t_0)$$

where R = the pounds of circulating water per lb. of steam, H = the total heat of steam at the condenser pressure, t_0 is the temperature of the inlet water, and t_2 that of the discharge.

At 28 in. vacuum the heat content of the steam is 1104.4 B.t.u. per lb. The temperature corresponding to this vacuum is 102 deg., but usually the temperature of the discharge, t_2, is about 15 deg. higher, or, say, 117 deg.; t_0 is, as you have given it, 70 deg.

Substituting the known quantities in this equation, we find that

$$R = 1104.4 - 102 - 15 + 32 \div (102 - 15 - 70)$$
$$= 1019.4 \div 17 = 60 \text{ lb. of circulating water per lb. of steam condensed.}$$

If you are condensing, then, 16,000 lb. of steam per hour, you will require 16,000 × 60, or 960,000 lb. of water per hour.

Thermal Conductivity of Gases

DOES THE heat conducting power of air increase as the pressure increases from a vacuum to say 100 lb. per sq. in.? Is there a difference in the conducting power of different gases, say, air, CO_2, oxygen, nitrogen and hydrogen? E. E.

A. Ordinarily the transmission of heat through gases is considered as being by convection, although, of course, radiation and conduction play a part. These three methods can be isolated only with the greatest difficulty, consequently a coefficient of heat conduction is of little value except perhaps in comparing one gas with another or a gas with a metal or liquid. Only relative quantities are available, at best.

There is, however, an equation suggested by Clark Maxwell by means of which the relative conductivity of any gas may be determined.

$$K = c \times n \times C_v$$

where K is the coefficient of conductivity in B.t.u. per sq. ft. per ft. length, per hr. per deg. difference in temperature, c is a constant to be determined by experiment, n is the coefficient of gas viscosity, and C_v is the specific heat at constant volume. As the coefficient of gas viscosity is dependent largely on the temperature, this equation may be reduced to the form

$$K = c \times C_v \times T^{3/4}$$

as suggested by Dalby. Here T is the absolute temperature. Marks gives the following values of conductivity for the gases mentioned. The pressure in each case is atmospheric. CO_2 at 32 deg. F. — 0.0079, hydrogen at 32 — 0.0775, nitrogen at 45 — 0.0127, oxygen at 45 — 0.0136, and air at 32 — 0.0126.

Pressure has but little influence on the conductivity. The variation over very considerable ranges of pressure is a negligible quantity.

Small Hydraulic Motor

WOULD THE flow of water from a ½-in. line under a pressure of 40 lb. per sq. in. be sufficient to operate a ½-hp. water motor? What would be the speed of this motor? G. A. K.

A. The energy available from a stream of water flowing from a pipe is equal to ½ mv^2, where m is the mass delivered in one second and is equal to w (the weight) divided by g (the acceleration due to gravity), and v is the velocity in ft. per sec. which is equal to $\sqrt{2gh}$ where h is the head in ft. Reducing this equation, we find the energy available

$$E = \tfrac{1}{2} \times w \div g \times 2gh = wh \text{ ft.-lb. per sec.}$$

w is equal to 62.5 (the weight of a cubic foot of water), times Q, the quantity of discharge in cubic foot per second, which in turn is equal to A, the area of the pipe in square feet, times V, the velocity, as before.

$$w = 62.5 \times A \times \sqrt{2gh}$$

As one horsepower is equal to 550 ft.-lb. of energy per second, the power available,

$$\text{hp.} = 62.5 \times A \times \sqrt{2gh} \times h \div 550$$

The actual internal area of a ½-in. pipe is 0.304 sq. in., or 0.00211 sq. ft.; h, the head corresponding to 40-lb. pressure is 40 × 144 ÷ 62.5 = 92 ft. Substituting these values, we find

$$\text{hp.} = 62.5 \times 0.00211 \times \sqrt{2 \times 32.2 \times 92} \times 92 \div 550 = 1.7$$

The efficiency of a small motor of this kind is usually quite low, say about 25 or 30 per cent. Assuming an overall efficiency of 30 per cent, we see that the brake horsepower available would be 1.7 × 0.30 = 0.51 hp.

For a motor of the Pelton wheel type the peripheral speed should, for best efficiency, be equal to one-half the jet velocity or in this case

$$v = \tfrac{1}{2} \times \sqrt{64.4 \times 92} = 38.5 \text{ ft. per sec.}$$

If we assume now that the diameter of the bucket wheel is 6 in., the speed would be 38.5 ÷ 3.14 ÷ 0.5 = 24.5 r.p.s. or 1470 r.p.m.

MANY A good idea is wasted because the man who has it won't work.

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Fuel and Living Costs

As engineers, we are uneasy at the constantly rising cost of fuel, and rightly so, for it will make the work of the power plant manager, in keeping down cost of operation, increasingly difficult. Not only will the fuel bill be larger, but with higher prices there is more temptation and tendency for coal producers to include as coal all possible material from the mine, regardless of the heat value. Greater care is necessary in making fuel contracts and in inspecting and testing fuel to make sure that dealers are living up to those contracts.

Also it is vital that all possible precautions be taken to prevent waste of heat units, not only in the burning of fuel and making of steam, but in the use of the steam. A routine of watchfulness must be devised and carried out rigidly; every part of the plant must be studied carefully to make sure that it is in the best possible condition, and being handled to the best advantage. The job of power plant manager is, more than ever, one of economic importance to the manufacturing plant, to the central station and to the community.

For, in the present day, a considerable part of every dollar spent for living goes to pay for power at some point. Power on the farm, in the mine, in the factory, for transportation by truck and train, for lighting and heating—all must be included in what we pay for food, clothing, rent and pleasures. And in every case the cost of fuel is a large part of the cost of power.

This widespread use of power has reduced the cost of living and increased production immensely; in fact, without it the work of the present-day world could not be done on the present-day scale of living by all the people and work animals in existence. But the fact that power is so large a factor in production, and that fuel must be our chief source of power makes the cost of fuel a matter of vital importance to every person in an industrial nation. It is vital to each one as an individual that this cost be kept as low as possible.

We should expect to pay the price necessary to give those who work for us a good living, to give reasonable return on the capital employed in industry, and to pay management for its help in increasing production. But wherever those who work, those who supply capital, or those who manage industry are lazy, inefficient or greedy, we have a right and a duty to protest. Labor and management each has a right to fair return for its efforts in proportion to the benefit it gives to the community. The owner of capital, big or little, has a right to fair return for lending to the community the saved and accumulated result of his labor. But no one of them has a right or should be allowed to receive a return which is unjust to the other divisions of the productive process, or to others in the same division. This is particularly true in the case of fuel production, for any overpayment to any one of the three factors has an immediate and harmful effect on the other factors in that industry and on all factors in every other industry. It increases the cost of fuel and of power for every industrial process, and, therefore, the cost of living for everybody.

More than in any other field of human effort is it important that a square deal be given to and by those engaged in producing and marketing fuel and that they be held rigidly to account by the public whom it is their duty to serve.

The Tamarack Power Plant

It is not often, in the building of a new power plant, that the operating engineer is given a free hand in its design and made responsible for the success or failure of that plant; but when he is given this opportunity, the resulting plant, regardless of how efficient it may be, is certain to be operable. By operable we mean that the equipment may be controlled and regulated with the least inconvenience to the operator.

In modern practice power plants are too often designed by men who, aside from producing a plant that is efficient and reliable, have no personal interest in its operation. Unintentionally, valves and fittings are often so installed as to make it extremely awkward for the operator to manipulate them. Equipment installed in cramped quarters which does not permit of sufficient elbow room to the attendant is certain not to receive as much attention as it would if it were installed in a more accessible location.

Operating engineers will therefore be interested in the leading article of this issue, since the power plant described therein is the product of an operating man's efforts. Twenty-five years of operating experience are reflected in every detail of construction of this plant and from an operating standpoint it is very nearly perfect. Every piece of equipment installed was carefully selected, not with regard to first cost, but with regard to its reliability and cost of operation. "First cost," says Mr. Tefft, the chief engineer, "must be given the least consideration. It is operating expenses that count; operating expenses are constant—they never stop. That is why equipment should be installed which will cut the operating expenses down to the lowest possible minimum."

Off Duty

Suppose, some night after a particularly gay time with the boys, you crawled into bed in the wee small hours of the morning, and in the few remaining hours between then and dawn, your much needed slumber was disturbed by a frightful nightmare—a nightmare in which you found yourself engineer of a power plant endowed with wheels, and that you, together with boiler, turbine, condenser, pumps, feed heaters and all were thundering down the road at some 60 miles per—you'd think you were in a heck of a fix, wouldn't you? And upon awakening, you'd probably heave a sigh of relief and thank your lucky stars that there "ain't no such animal."

In forming the latter conclusion, however, you may be somewhat mistaken, and it will only be necessary for you to take a trip over to Sweden, to see your dream realized. There, upon the lines of the Swedish State Railways you will find "such an animal" in the form of a locomotive, quite harmless, however, and under perfect control of the engineer.

"But," you protest, "the thing you described was certainly not a locomotive. A locomotive may be a power plant on wheels, but it has no condenser, nor turbines such as you speak of."

True enough, according to your general conception of a locomotive, but this one we have reference to is something different from the ones we are familiar with in America, and not only is it equipped with a condenser and turbine, but also with soot blowers, air preheater and an induced draft fan!

This machine, which embodies such profound variations from conventional designs, that it constitutes an entirely new departure in locomotive engineering, was built by the Ljungstrom brothers, already famous by their development of the Ljungstrom turbine.

About five years ago Mr. Frederick Ljungstrom set himself to study the steam locomotive with a view to improving its performance. He received occasional assistance from his brother, Mr. Birger Ljungstrom, and it was in the latter's factory near Stockholm that the work was carried out. The result of this work is a machine radically different from any locomotive ever constructed, but one in which every requirement as to efficiency, reliability and railroad practice has been fully met.

To give the reader an idea of what this machine is like, we will enumerate some of the more important features as given in a recent issue of Engineering of London.

To begin with, it is 72 ft. long, weighs 126 tons, has a tractive effort of 24,000 lb. and is capable of maintaining a speed of 60 miles per hour. It is driven through double reduction gears by an 1800 hp. steam turbine exhausting into a specially designed air condenser. Feed water is heated in three feed water heaters, each heater taking exhaust steam at a different pressure and therefore at a different temperature from same auxiliary apparatus so that the temperature is progressively and efficiently raised to the desired point. Air to the furnaces passes through an air preheater where it is heated to a temperature of about 300 deg. F. by the escaping gases of combustion. A turbine driven induced draft fan running at 10,000 r.p.m. creates the necessary draft above the fuel bed. Steam is superheated in a superheater having 861 sq. ft. of heating surface. Automatic soot blowers are provided for keeping the boiler and air heater tubes clean, and a forced feed lubricating system supplies oil to all parts of the machine. Turbine driven condensate and boiler feed pumps are provided.

Such, in brief, is a description of the Ljungstrom locomotive. Acting with the full courage of their convictions, the Ljungstrom brothers constructed this machine, not on a small scale, or in an experimental manner, but equal in size to the largest standard main line locomotive used on the Swedish State Railways. It was built for service and for many months past it has been operating on the Swedish Railways under actual traffic conditions with entire success.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.

Develop Water Power Sites.

Promote Health and Safety in Power Plants.

Handle Coal and Ashes Mechanically.

Employ Engineers for Engineering Work.

Systems of Ash Discharge

By David C. Spencer

ONE of the problems which constantly confront boiler room engineers and operators is the matter of cleaning fires and discharging the ash. Boiler operation may be classified in two groups. There is the station or plant whose load changes frequently, sometimes slightly, at other times in violent swings. The boilers may be delivering steam at 100 per cent of rating at one minute, and be required to deliver 200 or 300 per cent of rating 5 or 6 min. later, with an equally sudden drop when the load goes off.

Then there is the station whose load is fairly constant for an extended period of time. Such changes as occur are gradual and can usually be anticipated. There are practically no sudden fluctuations.

It sometimes happens that one station will combine the characteristics of both classes; in other words, certain boilers are depended on to carry the average load,

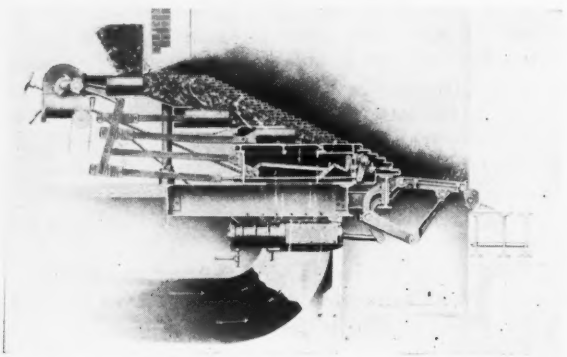


FIG. 1. CROSS SECTION OF TAYLOR STOKER EQUIPPED WITH POWER PUMP

operating at the point of their maximum efficiency, while one or more additional boilers would be carried as standbys to pick up the excess load when required. Each of these classes presents its own peculiar problem in the matter of cleaning fires.

The power dump used with the underfeed type of stoker for cleaning fires where fluctuating conditions exist, gives the operator absolute control over his fire. He can, if necessary, increase the rate of coal feed to meet almost any contingency that may arise. It provides a variable rate of ash discharge that functions at the will of the operator. It requires the minimum amount of time to drop the dump plate, so that the accumulation thereon may fall into the ash pit, and return the plate to its normal running position. Steam flow meter charts of operation show practically no interruption to steaming as the result of the dumping period.

In the second class of operation, the problem is entirely different. With a fairly constant load, the operator seeks, naturally, to operate his plant at the point of maximum efficiency. There is comparatively little need for the ability to clean fires instantly. Rather, there is urgent need for as nearly as possible, clean fires at all times. The ideal way to maintain clean fires is to discharge the ash as rapidly as it forms—in other words, by means of continuous ash discharge at a rate proportional to the rate of combustion. This is accomplished by the rotary ash discharge which is of more recent development and has been brought to a high state of perfection.

One of the essential features of the Rotary ash discharge is a deep ash pocket. It is extremely difficult to handle hot ash. After the ash has become cool, it can readily be broken up and discharged. The ash pocket serves as a space in which ash may be treated or conditioned for discharging. The conditioning of the ash involves the final burning out of any combustible which it may contain after it leaves the stoker proper, and the cooling of the refuse.

To provide for this, the ash pocket is divided horizontally into two sections. The upper section is flanked by a grate somewhat similar to the extension grate of the stoker itself. This is known as the lower extension grate. It is provided with ports through which air may be admitted in any desired quantity. The combustible which remains in the ash after it reaches the pocket continues to burn while in this section and until it passes below the bottom of the lower extension grate. This results in reducing to a minimum the combustible in the final residue and, therefore, in increased combustion efficiency.

The lower portion of the pocket is flanked by cast-iron plates known as crusher plates. These provide a surface against which the clinker can be crushed. In all double set arrangements of the stoker, there are crusher plates on each side of the pocket. This is also true of single set arrangements where two crusher rolls are provided. When only one crusher roll is used, the

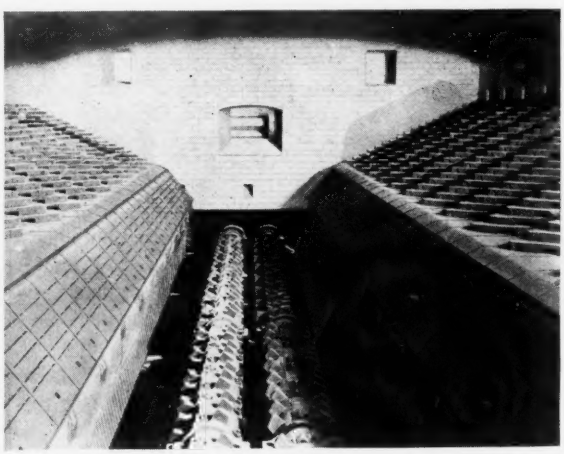


FIG. 2. STOKER IN SOLVAY PROCESS CO. SYRACUSE PLANT, FITTED WITH ROTARY ASH DISCHARGE

crusher plate is on the stoker side of the pocket and the bridgewall side is lined with a rigid cast-iron plate.

The crusher plate is movable so that the gap between the plate and the roll may be adjusted to any size suitable for easy handling by any ash disposal system. It also permits a certain degree of variation in the rate of ash discharge although this is a secondary function. Finally, it provides a means whereby the ash pocket may be emptied when the stoker is off the line for cleaning or overhauling. The accompanying illustration of one of the furnaces at the Syracuse plant of Solvay Process Co. shows one section of the crusher plate in running position, while the other sections are wide open.

The crusher rolls are the operating element of this system of ash discharge. They consist of cast-iron shells mounted on a steel shaft which has a square cross section. The shells are built up in sections for convenience and are armed with teeth that have a triangular cross section. These teeth are made of special cast-iron which is very durable and are made removable for ready replacement. The design of the teeth is such as to provide the maximum crushing force with the least strain on the rolls or mechanism.

The rolls may be operated by the stoker drive or independently as desired. In either case, provision is made for varying the speed of the rolls independently

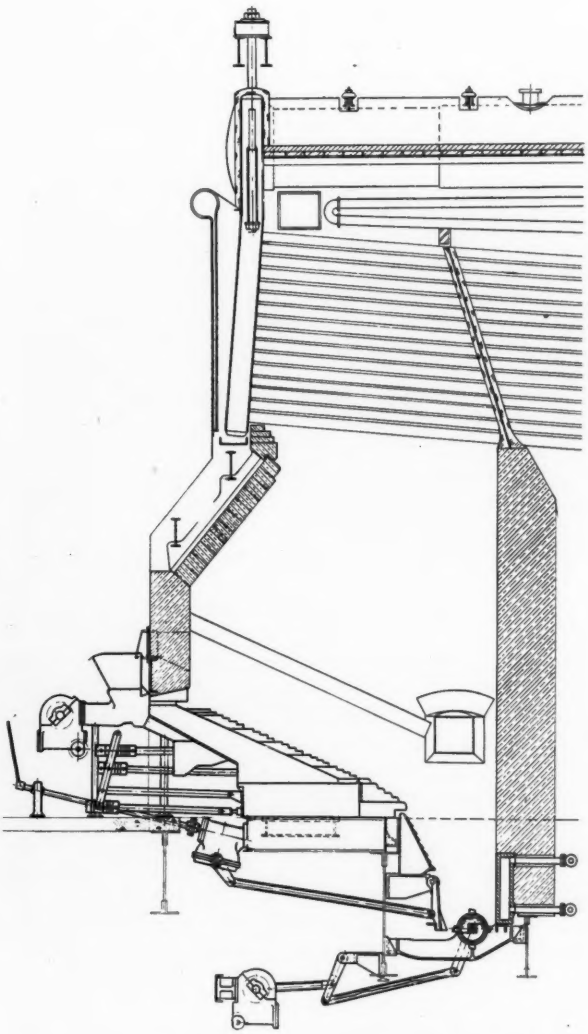


FIG. 3. CROSS SECTION OF STOKER WITH SINGLE-ROLL ROTARY ASH DISCHARGE

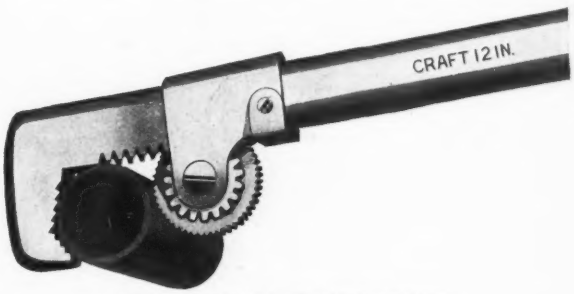
of the stoker so that the operator may regulate the proportionate rate of ash discharge. In all two roll arrangements, the rolls are made to rotate away from each other at the top, while in the single roll arrangement, the roll rotates toward the stoker.

The advantages of the rotary ash discharge system are: It provides a space in which combustible may be consumed to the ultimate degree, and in which the ash may be cooled. It also provides a means whereby the ash and clinker may be continuously crushed and discharged, and insures practically constant furnace conditions.

New Self-Adjusting Wrench

AN INGENIOUS device in the form of a pipe wrench has recently been placed upon the market by the Coleman Railway Supply Co., New York City. This wrench, known as the Craft wrench, is shown in the accompanying illustration, and, as may be noted, consists of a head and a movable jaw held in place by a spring. The movable jaw is fitted with a toothed disc, which, together with the stationary head, grips the pipe with a 3-point contact.

By merely dropping the head of the wrench into place over the pipe, the spring in the handle slides the movable jaw into place against the work. A push on the handle causes the jaws to grip—the harder the push,



CRAFT SELF-ADJUSTING WRENCH

the greater the grip. Pulling the handle releases the work instantly. In other words, the wrench follows the pipe around in contact with it, releases when lifted, but is ready to grip instantly when the handle is again pushed down.

The rotating disc feature causes a different surface to be presented to every diameter of pipe; this gives the jaws about eight times the ordinary wear.

Transformer Load Indicator

A TRANSFORMER load indicator for determining the load of distribution transformers and for many other practical purposes is being manufactured by the Westinghouse Electric & Manufacturing Co.

The indicator is a device made for mounting in place of the drain plug or, preferably, in the side of the tank wall a few inches below the oil level in a distribution transformer for the purpose of indicating whether any predetermined temperature of the transformer has been reached or exceeded. When the predetermined temperature has been reached, a yellow semaphore, or flag, drops into view to indicate the fact. Since the flag is of a distinctive color, and has an area of about 2½ sq. in., it can be readily seen from the street by a watchman.

The most important use for this device is to indicate when a transformer is overloaded, but it can also be utilized to determine whether transformers operating in a bank or in parallel are properly dividing the load. Underloading can also be detected by setting the indicator to trip at a low temperature, failure to trip at this

low temperature being an indication that the transformer is underloaded.

The load indicator consists in general of two parts—the indicating mechanism and the plug. The plug portion replaces the regular transformer drain plug or the special plug now being provided in Westinghouse distribution transformers a few inches below the oil level, and it can be inserted in the transformer tank either in

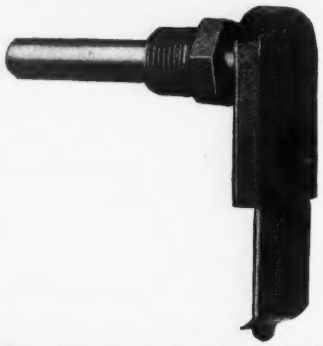


FIG. 1. WESTINGHOUSE TRANSFORMER LOAD INDICATOR

the storeroom or on the line. The pipe is a tube closed at the inner end and enlarged to a standard pipe thread with a hexagonal nut at the outer end. The tube, when in position, is surrounded by the transformer oil.

The indicating mechanism consists of a base plate, tube, bimetallic strip, flag, adjusting rig and cover. The tube fits the inside of the plug and has a threaded piece at the end which engages the nut in the end of the plug.

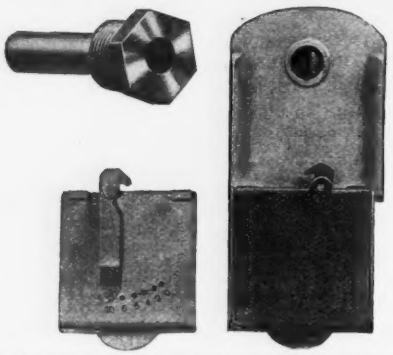


FIG. 2. DISASSEMBLED VIEW OF WESTINGHOUSE TRANSFORMER LOAD INDICATOR SHOWING YELLOW FLAG IN TRIPPING POSITION

By means of this threaded piece, the indicating mechanism can be inserted in the plug with a turn or two after the transformer is hung and can then assume a vertical position without danger of falling out.

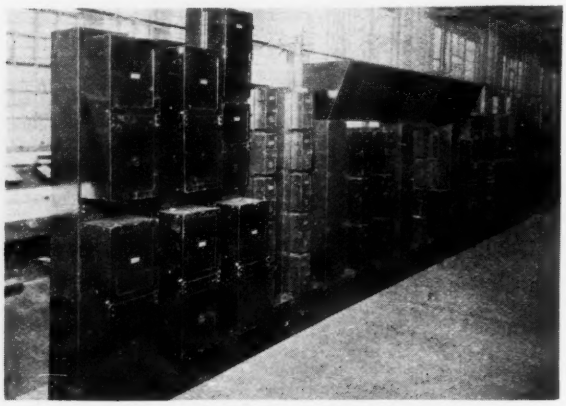
The bimetallic strip is set in the end of the tube while the free end, projecting beyond the end of the base plate, latches the flag in position. The flag is held until, through an increase in temperature, the bimetallic strip bends enough to unlatch it; then it drops by gravity. The top of the flag is bent over and, after dropping, engages the bottom of the base plate, which is bent upwards. The flag is reset by simply pushing it back in place.

The indicator can be set to trip the semaphore at any predetermined temperature within the range of adjustment.

Safety Switchboard for New York Stock Exchange

A SWITCHBOARD that has several claims to interest has recently been installed in the Stock Exchange Building, New York City, by the General Electric Co. It is the largest board of its kind to be installed as yet, consisting of 84 safety enclosed switches mounted together, and used to control the lighting and power circuits of the building. These safety enclosed switchboards, which are a comparatively new development, are so designed that they may be built up, as occasion arises, in the same manner as a sectional bookcase.

The board in question handles the 250-v. direct current power supply, and the 250/125 v. lighting circuits, the units comprising it being divided into switchboards handling from 5 to 20 circuits apiece. Each group is fed through a remote control, double throw



VIEW OF SAFETY ENCLOSED SECTIONAL SWITCHBOARD

solenoid circuit breaker on the main switchboard. One reason for adopting this type of board was that it was desired to meet existing conditions in the engine room; and the flexibility of the sectional board is such that this is accomplished very satisfactorily.

The board itself is made up of a series of horizontal bus boxes mounted end to end, and forming a sort of duct for carrying the feeder and distribution wiring of the board. The wiring units for the individual switches are secured to the bus boxes in vertical columns, which may be added to as desired, and on which the switches themselves are mounted. Copper connections are used throughout, a bus being run in the horizontal duct, or bus box, and tapped at the vertical tiers, or columns. The vertical boxes are drilled at points back of the switches and terminals supplied. From these points insulated wire is run through knockout entrance holes in the back of the switch casing to the switch studs.

The boxes which form the columns are of punched sheet steel, and have removable front plates to which the switches are fastened. The front plates are drilled to correspond to the knockout holes in the switch box, so that when the cover of the box is removed the taps from the cable in the column can be fed through the holes. The front plate is then secured to the box, and the tap terminals fastened to the switch studs.

All Steel Flexible Coupling

A FLEXIBLE coupling of all steel construction has recently been placed on the market by the Steel-Flex Coupling Corp., of Detroit, Mich. In place of the rubber, leather, fibers, etc., that are frequently used, this coupling is constructed, as shown in Fig. 1, with elastic steel springs.

The helical driving coils of these couplings are formed of rectangular tempered chrome vanadium steel bars. These coils, one within the other, are mounted on machine steel plugs. On the end of the coils are shrunk on steel headers, binding these parts into a continuous flexible unit. Flanges are attached by means of cap screws.

The coupling is designed to operate when the center lines of driving and driven shafts are set at an angle to each other, when center lines are offset, or when there is oscillation of either or both shafts. The coupling cushions the starting and stopping loads by expansion and contraction of the coils. Lateral compression of the springs also permits of end play of the shafts.

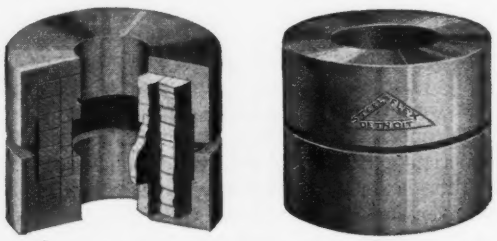


FIG. 1. CUT AWAY VIEW OF STEEL SPRING FLEXIBLE COUPLING SHOWING ARRANGEMENT OF SPRINGS
FIG. 2. TYPE OF COUPLING USED FOR LIGHT DUTY

This coupling is suitable for high speeds, and is made to run in either direction. They are made in all standard shaft sizes for all power transmission services, being used with generator sets, line shafting, motor-driven machines, etc. Figure 2 shows the coupling for use with small shafts. For heavy duty, a flange type coupling is used.

Death of Charles G. Cooper

CHARLES GRAY COOPER, for 45 yr. identified with the C. & G. Cooper Co., Engine Builders, Mt. Vernon, Ohio, died at his home in Mt. Vernon, Aug. 4, 1922, after an illness dating from April, 1918.

He was born in Mt. Vernon, Dec. 11, 1845, and was the son of Elias Cooper, who, with his brother Charles Cooper, founded The C. & G. Cooper Co. ninety years ago. He was educated in the public schools of Mt. Vernon and at Oberlin College.

Mr. Cooper, as a young man, served in the Civil War. He became connected with the Cooper Company in 1866, at which time it was a partnership. Later on, at its incorporation in 1898, he became secretary and served in this capacity until the death of the president, F. L. Fairchild, in 1912, when he was made president. He served as president until his illness in 1918, when B. B. Williams was made president and Mr. Cooper became chairman of the board of directors, which, as an honorary title, he held until his death.

Mr. Cooper was one of the pioneer engine builders of this country and practically his entire life was spent in the developing and building of steam and gas engines.

He was a member of the Masonic bodies of Mt. Vernon and for many years an officer of the Congregational Church. His activities were numerous and he was held in high esteem by all who knew him.

The members of his immediate family who survive him are a widow, two daughters and a son.

A. I. E. E. Appoints Committees

AT THE first meeting of the Board of Directors of of the American Institute of Electrical Engineers for the administrative year beginning Aug. 1, 1922, held in New York, on Tuesday, Aug. 8, President Jewett announced the committee appointments. The chairmen of the committees appointed are as follows:

Standing Committees: Board of Examiners, H. H. Norris, New York. Code of Principles of Professional Conduct; Schuyler Skaats Wheeler, Ampere, N. J. Co-ordination of Institute Activities, W. I. Slichter, New York. Edison Medal, Edward D. Ames, New York. Executive, Frank B. Jewett, New York. Finance, L. F. Morehouse, New York. Headquarters, E. B. Craft, New York. Law, H. H. Barnes, Jr., New York. Meetings and Papers, E. E. F. Creighton, Schenectady, N. Y. Membership, R. B. Howland, New York. Publication, Donald McNicol, New York. Public Policy, H. W. Buck, New York. Research, J. B. Whitehead, Baltimore, Md. Safety Codes, H. B. Gear, Chicago. Sections, A. W. Berresford, Milwaukee, Wis. Student Branches, C. F. Harding, Lafayette, Ind. Standards, Harold Pender, Philadelphia, Pa.

Technical Committees: Educational, C. E. Magnusson, Seattle. Electrical Machinery, B. A. Behrend, Boston. Electrochemistry and Electrometallurgy, J. L. Yardley, Pittsburgh. Electrophysics, F. W. Peek, Jr., Pittsfield, Mass. Industrial and Domestic Power, H. P. Reed, Milwaukee, Wis. Instruments and Measurements, P. A. Borden, Toronto. Iron and Steel Industry, E. S. Jefferies, Hamilton, Ont. Lighting and Illumination, G. H. Stickney, Harrison, N. J. Marine, G. A. Pierce, Jr., Philadelphia, Pa. Mines, Graham Bright, Pittsburgh. Power Stations, R. F. Schuchardt, Chicago. Protective Devices, H. R. Woodrow, New York. Telegraphy and Telephony, R. E. Chetwood, New York. Transmission and Distribution, Edward B. Meyer, Newark, N. J.

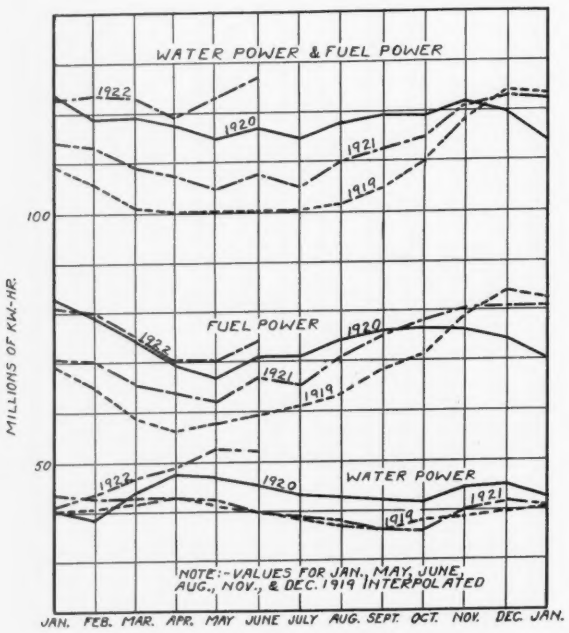
In accordance with the by-laws of the Edison Medal Committee, the Board of Directors confirmed the appointment by President Jewett of new members of the Edison Medal Committee, as follows: Gano Dunn, New York; F. A. Scheffler, New York; and W. R. Whitney, Schenectady,—for terms of 5 yr. each. The Board also elected three of its membership as members of the Edison Medal Committee for terms of 2 yr. each, namely, E. B. Craft, New York; G. Faccioli, Pittsfield, Mass.; William McClellan, New York.

THE WEST PENN POWER CO. completed its new high tension power line between Rivesville and Grafton, W. Va.; 66,000 v. are carried by this new high tension transmission line from the plant at Cheaters Haven, Pa.

Production of Electricity Reaches Maximum in June

THE REGULAR monthly statistics on the production of electricity in the United States prepared by the United States Geological Survey of the Department of the Interior show that the average daily production by public utility power plants in June was 127,700,000 kw.-hr., the highest rate yet reached. December, 1919, with an average daily output of 124,200,000 kw.-hr., comes nearest to this record. The increase over May of this year amounted to about 3.5 per cent. As the daily output by water power was practically the same in June as in May, the increase in output was in fuel burning plants.

The proportion of the total power produced by water power was, in May, 43 per cent and in June



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITY PLANTS IN THE UNITED STATES

41.4 per cent. Power produced by fuels in June necessitated the consumption of 2,489,581 T. of coal, 911,272 bbl, of fuel oil, and 2,352,150,000 cu. ft. of natural gas.

Ordinarily, the maximum production of electrical power in public utility plants occurs during the winter months and it is therefore rather surprising to find the record broken in June. On this point, the opinion is advanced by the compiler of this report that this increase has probably been due to the fact that the industries which are out of coal have turned to public utility companies for power to operate their plants.

WESTERN STATE HOSPITAL of Pennsylvania is to put in a new $40,000 power house and electric light plant to replace the existing plant, to be devoted to other purposes. The new plant will be ready to meet all demands of the over 900 patients and attendants, early this fall.

News Notes

THE FALL term of the Three Months' Course in Refrigeration Engineering at the Siebel Institute of Technology, Chicago, will start Sept. 12, 1922. This course, which was temporarily suspended during the war has been greatly augmented. The Siebel Institute offers to those interested in the subject of refrigeration engineering an opportunity to obtain a thorough scientific training in a short period of time. All of the numerous other studies taught by state universities and colleges, requiring two to four years to complete, have been eliminated and only the most essential subjects are given.

THE FOUR national engineering societies, the offices of which are at No. 29 West 39th St., New York, maintain a free employment bureau which advises that readers who are officials of or connected with organizations in which a central personnel department is not maintained, are at this time given a cordial invitation to make free use of the bureau. The administration of the bureau is in charge of W. V. Brown.

THE FOLLOWING power plant turbines and other power accessories, intended primarily for power use in the United States Shipping Board vessels, now rendered surplus, were recently placed on sale at Sparrows Point, near Baltimore, Md.: 4 Curtis turbines, 5000 shaft hp.; 4 reduction gears for the above turbines; 4 Yarrow water-tube boilers, 4905 sq. ft. heating surface; 3 turbine-driven forced draft blowers; 80 various pumps for oil and water, sizes from 4 by ¾ by 5 in. to 12 by 8½ by 12 in.; three 50-kw. generator sets, turbine driven; 8 oil coolers; 6 marine distillers. All the above are offered "as is, where is," without guarantee as to quality. F. M. Carroll is the sales manager at Sparrows Point for this material.

THE COLORADO ATOMIZED FUEL CO. expects to have ready for business in September its $150,000 Denver plant. When this is got going, other plants will be opened in Colorado Springs and Pueblo. It has not been a great while since coal dust was considered an unwelcome dirt, and now fortunes are being spent to pack this dried dust properly in air-tight containers so that it may be carted wherever wanted and there give us wonderful heat.

INCREASE IN the demand for electric light and power in the City of Scranton, Pa., has necessitated the extension of the plant of the Scranton Electric Co. Equipment for the extension, including a large amount of transmission apparatus, has been ordered from the Westinghouse Electric & Manufacturing Co.

THE PUBLIC WORKS department of the city of Lynchburg, Va., is now under the direction of Richard W. B. Hart, assistant engineer, who has been made acting director. Mr. Hart was 13 months in France as Captain of the 52nd Engineers, N. A.

THE AMERICAN WATER WORKS & ELECTRIC CO. of New York has completed its $900,000 purchase of the common stock of the Potomac Public Service Co., and announced its intention of a further contemplated investment of $1,000,000 on improving the plant efficiency, equipment, transmission lines, substations, etc.,

through this mountain inter-state section of Virginia, West Virginia, Maryland and Pennsylvania. Several of these lighting service and general power plants were recently given a vigorous overhauling but the scope of this utility corporations business is to be broadened.

THE KENTUCKY AND WEST POWER CO., a $600,000 corporation, plans the extension of its electric transmission lines to Pikesville, Kentucky. A new power house is planned for this company, when the Kentucky line is completed.

THE CITY-MANAGED town of Radford, Va., has bonded itself to the amount of $225,000, and is taking over the operation of its own community utilities, including power plant, electric plant, for light and power, and the street railway system. It had previously expended a $350,000 bond issue on such municipal enterprises as waterworks, sewage disposal, trash removal, and the like.

THE CITY OF SEATTLE, Washington, has placed with the Westinghouse Electric & Manufacturing Co. additional orders for equipment for its new Gorge Plant. This plant is located on the Skagit River about 100 mi. from the city of Seattle and will tie in with the other municipal plants now in operation. Its initial capacity will be 60,000 kv.a., but an ultimate capacity of 180,000 kv.a. is planned. The ultimate capacity of the entire municipal system will be 500,000 kv.a.

THE FIRST STEP toward the completion of a comprehensive construction program for the Louisville Gas & Electric Co. has been taken with the placing of orders for the purchase of a 27,000-hp. turbo-generator. The present building, known as Waterside Station, will be enlarged to accommodate the new unit, and additional boiler capacity and switching equipment will be installed. Construction work will be started immediately, and it is expected that the new equipment will be in operation by the end of 1923.

The present station is one of the largest and most modern generating plants in the South, with a capacity of 63,650 hp., which will be increased by the installation of the new turbine to a total of 90,650 hp.

GRANITE FALLS, MINN., has awarded a contract to the Fulton Iron Works Co. for a three-cylinder, 285-b.hp. Diesel engine to be installed in its municipal lighting plant. The engine will be direct connected to a 190-kw. alternating current generator with belted exciter.

THE FLORANDIN EQUIPMENT CO. has been organized by C. H. Florandin, with offices at 110 East 40th St., New York, to act as representatives of the Conveyors Corporation of America, Chicago. The new organization will also do a general contracting business in and around boiler plants and industrial plants located in New York City and its vicinity, erecting and installing the lines of equipment which the organization handles.

THE SCHAEFFER & BUDENBERG MANUFACTURING CO., with works and general offices in Brooklyn, N. Y., on Aug. 1 consolidated with the American Steam Gauge & Valve Mfg. Co., Boston, Mass. These two companies, while operating as one, will continue the manufacture at their respective plants of their various instruments for measuring pressure, temperature, power, speed, etc. The Schaeffer & Budenberg Co. retains its full original title, while the American Steam Gauge & Valve Co. becomes a "division" of the Schaeffer & Budenberg organization. No radical changes are to be made in their executive personnel. The factory line-up also, which in both cases embraces operatives of long training in highly specialized departments, remains undisturbed.

THE JOHNS-PRATT CO., of Hartford, Conn., has established a Boston office at 161 Summer St., which is in charge of Daniel Fitts and Harold E. Morse. It is intended to have complete representation at this office for the products of the company.

THE MOORE Steam Turbine Corporation has recently opened its own offices as follows: New York, Domestic, 50 Church St., S. G. Peticolas, manager; New York, Export, 50 Church St., Maximilian Aviles, manager; Chicago, Ill., 10 South La Salle St., S. S. Wilson, manager.

G. A. BINZ, sales manager of the American Steam Gauge & Valve Mfg. Co., Boston, Mass., has been appointed sales manager also of Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y., upon the consolidation of these two companies Aug. 1. Mr. Binz's headquarters are at Berry and South 5th Sts., Brooklyn, N. Y.

E. W. ROSSITER has been appointed engineer of construction for Freyn, Brassert & Co. Mr. Rossiter was previously chief engineer of the Interstate Iron & Steel Co., Calumet River, Chicago, and, prior, with the American Sheet & Tin Plate Co., the Minnesota Steel Co., and the Canadian Steel Corporation, Limited, at Ojibway, Ontario.

J. S. COLT, former manager and vice-president of the Wilmington Electric Appliance Co. of Wilmington, Delaware, has succeeded J. C. McLaughlin as manager of the Potomac Electric Appliance Co., of 607 14th St., Washington. His transfer here is in the light of a promotion, earned by service in this department of these power interests at Wilmington and other cities.

THE BOUSTEAD ELECTRIC & MANUFACTURING CO., Inc., of Minneapolis, Minn., have just been appointed Northwestern distributors for the Ideal Electric & Manufacturing Co. of Mansfield, Ohio. The Boustead Electric & Manufacturing Co. have for years specialized in rebuilt motors and generators and at the present time maintain one of the largest and best equipped electrical repair shops in the Northwest.

THE WESTINGHOUSE International Trade Special, carrying 33 cars of equipment for the electrification of the Chilean State railways, was started by wireless on its long journey from the East Pittsburgh, Pa., works of the Westinghouse Co. to Valparaiso, Chile.

E. M. Herr, president of the Westinghouse Co., closed the switch which set the train in motion. This switch which was mounted on a pole about 150 ft. from the railroad track on which the train was standing and one-half mi. from KDKA, the Westinghouse Co.'s broadcasting station at East Pittsburgh, caused KDKA to broadcast a special code signal, consisting of a series of dots and dashes. The special radio receiving apparatus,

set up in the cab of the locomotive and including an aerial mounted on top of the engine cab, was set to pick up only the special code signal broadcasted from KDKA. When this signal was broadcasted, the radio receiving apparatus on the locomotive picked it up and by means of a selector switch, the control circuits in the locomotive were closed and the train was set in motion and accelerated automatically.

THE DETROIT STOKER CO. has purchased the plant formerly occupied by the Van Blerck Motor Co., Monroe, Mich., for the manufacture of Detroit Underfeed and Detroit "V" type stokers. The plant is well located, with good shipping facilities. It consists of several large fireproof buildings with nine acres of land, and plenty of room for expansion. The Detroit Stoker Co. will continue to maintain its general offices and engineering department in the General Motors Building, with plant at Monroe.

THE TECHNICAL STAFF of the Bureau of Internal Revenue at Washington is in need of valuation engineers in general mining, coal mining, oil and gas, and the forest industry. The positions pay from $3600 to $4800 a year. The United States Civil Service Commission will receive applications until Oct. 1. No written examination will be given; the ratings will be based upon education, training, experience, and physical ability. The duties involve estimation of quantities, market values, value of equipment, cost of development, etc. Full information and application blanks may be secured from the United States Civil Service Commission, Washington, D. C., or the civil service board at the postoffice or customhouse in any city.

Books and Catalogs

HYDRAULICS WITH WORKING TABLES, by E. S. Bellasis; size 5½ by 8¼ in., 348 pages, cloth, New York, 1922.

In this, the third edition, the book has been subjected to careful revision and has been brought up to date. The chief object is, as stated in the preface, to deal thoroughly with the facts, laws and principles of hydraulics, keeping in view their practical aspects.

In the solution of problems dealing with hydraulics the apparently widespread use of erroneous coefficients has led to much waste and it is hoped that some fair degree of accuracy may be attained in the use of hydraulic formulas, in the proper application of these empirical coefficients. To remedy this condition has been the object of introducing fresh discussions of the most important coefficients and in making specific recommendations as to their use. Many examples and practical problems are included as well as comprehensive tables for working them out.

New material has been added on weirs, surfaee curves upstream of weirs, discharge measurements by means of pipe diaphragms, etc. An idea of the comprehensive character of the book may be gained by a review of the chapter headings: General principles and formulas, orifices, weirs, pipes, open channels—uniform flow, open channels—variable flow, hydraulic observations, unsteady flow and dynamic effect of flowing water.

While there are of necessity many mathematical equations used, needlessly long mathematical investigations have apparently been carefully avoided. As a general thing, the material has been presented in a concise and practical manner and is readily understood.

"PREVENTING CORROSION OF BOILER TUBES" is the title of an exceedingly interesting bulletin, No. 4C, just published by the National Tube Co., Pittsburgh, Pa. The subject matter constituting this bulletin has been divided into three parts, covering separately, locomotive, stationary, and marine types of service.

While the conditions affecting corrosion of boiler tubes may frequently be the same, the inherent differences of the three main fields of boiler service vary sufficiently to warrant separate treatment of corrosion problems in each field.

Three authoritative articles have been incorporated as the basis of this bulletin, each written from the particular point of view of either the locomotive, the stationary, or the marine engineer. The combined information gives the more important data available on the problems involved, and, taken individually, each article reflects the main accomplishment of research in their respective fields.

FROM NASH ENGINEERING CO., South Norwalk, Conn., we have received Bulletin No. 25 on the Jennings Hytor vacuum heating pump, size M, electric motor driven.

FORMET is the title of a booklet recently issued by the Perolin Co. of America, describing a method of treating water to eliminate and prevent rust, corrosion, congestion and discoloration.

THE PRODUCTS of the Auburn Foundry Corporation, Auburn, Ind., are fully described in their new 24-page illustrated catalog, entitled Auburn Hand Stokers and Clear Cut Grates.

SPRAY ENGINEERING CO., Boston, Mass., has just issued a 4-page circular describing the application of the Spraco Air Washer to an enclosed system of generator ventilation.

E. KEELER CO., 50 Church St., New York City, has recently issued a 20-page bulletin, showing the general design of Keeler boilers, and a comprehensive table of dimensions of all important sizes with setting plans.

THE BOILER ROOM Improvement Co., 8 So. Dearborn St., Chicago, describes its Eclipse Smoke Indicator in a new circular entitled "Why Fear the Smoke Inspector?"

SCIENTIFIC STREET LIGHTING is the title of a new guide to good street lighting practice which has recently been issued by the Holophane Glass Co., 342 Madison Ave., New York.

THE BROWN Instrument Co., of Philadelphia, Pa., has issued a new resistance thermometer catalog which explains the theory of resistance thermometry, the various types of instruments which are made, and the merits of each type.

ALLIS-CHALMERS MANUFACTURING CO., of Milwaukee, Wis., has recently issued a new bulletin, No. 1124, in which is described its line of synchronous motors. The constructional features of these motors are described in detail and their application is pointed out by means of numerous halftone illustrations.